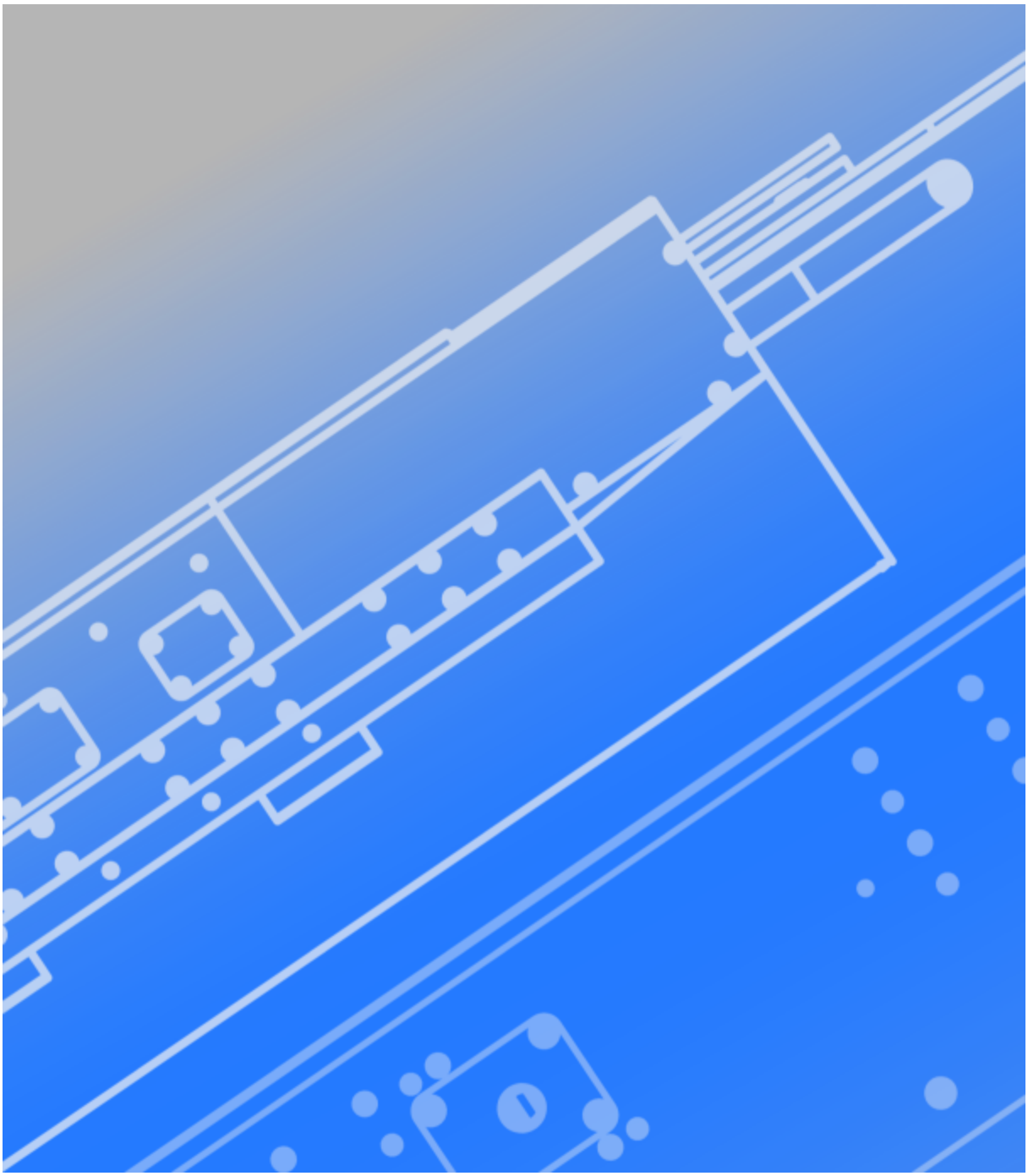
Picosecond Laser

HYPER RAPID 25

User's Guide



Picosecond Laser
HYPER RAPID 25

User's Guide

Opelstr. 10
67661 Kaiserslautern
Germany

www.LUMERA-LASER.com
info@LUMERA-LASER.com

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Delivery subject to availability; right of technical modifications reserved.

This User's Guide replaces all previous versions.

Contents

1 Introduction

The picosecond laser HYPER RAPID 25 is special equipment which must only be used by qualified and trained personnel following the instructions of this manual.

The HYPER RAPID 25 laser emits laser radiation that can permanently damage eyes and skin.

The laser contains high voltage power supplies. Careless use could result in electric shock. It also contains high electro-magnetic and high magnetic fields. Users with pace-makers and/or surgical implants shall not work beside or with the laser system without first consulting their physician. Credit cards or any media with magnetic recording could be damaged by the magnetic field. This kind of data storage has to be kept away from the system.

LUMERA LASER GmbH does not accept responsibility for any injury arising from misuse of this equipment.

Not observing all instructions of this manual may result in injury, damage the laser and/or void of warranty. Breakage of any seal without prior written authorization of the manu-facturer will void all liabilities of the manufacturer and warranty claims of the user.

The instruction and descriptions provided in this User's Guide comply with the current state of the technology at the time of publication. We ask for your understanding that no claims can be made based on information or illustrations contained in this manual. LUMERA LASER reserves the right to make changes and corrections in documents at any time without prior notification. This manual replaces all former versions.

1.1 Typographic conventions

The following typographic conventions are used in this user's guide:

Convention	Explanation
	Indicates that non-compliance with instructions or procedures could lead to physical injury or even death or could cause damage to the HYPER RAPID 25 laser.
	This symbol indicates that the component is heavy. Lifting and moving the component should be done with an adequate support.
	This symbol indicates corrosive, irritant components. E.g. chiller water needs to be handled carefully especially during water change. Safety gog-gles, gloves and protective clothing are required.
	This symbol indicates a magnetic field.

Convention	Explanation
	Adequate laser safety goggles have to be worn.
	Indicates additional relevant information and tips.
bold	Indicates references to names of interface elements.
`monospace`	Indicates system output and system elements for example, file names and paths.

1.2 Intended Use

The HYPER RAPID 25 laser is a highly innovative ultrashort pulse laser of the newest generation. The system is meant for industrial micromachining. The picosecond pulses lead to a so-called *cold ablation*. This guides to a new quality of the machined area, because any disturbing thermal side effects like microcracks, burr or recast are completely excluded. This laser is suitable for high quality micromachining of nearly any material with spatial resolution in the µm / nm range. This rugged laser is built for 24/7-operation in an industrial environment. Working with the laser is without creating any mechanical forces or tool abrasion.

Sample applications are drilling, cutting, marking, hardening, polishing, micro-welding and surface structuring of various materials

In this laser system all advantages of an ultrashort pulse laser and an industrial laser with excellent beam quality, high power, high repetition rates and high reliability together with low operation costs are combined.

The system is designed for material processing in atmospheric environment, horizontal alignment, relatively motionless during emission and free of vibration. It is not qualified for under-water use or zero gravity. Furthermore demonstrative applications like laser-shows are not allowed. Combustible or explosive materials may not be processed by the laser. Please note that equally chemical or physical reactions could result in such products.

All safety directives and instructions have to be followed. Manipulation or opening the system is prohibited. The manufacturer does not take responsibility for damages due to inappropriate use as well as not-intended use.

1.3 Precautions and Warnings

In case of an emergency, immediately hit the **Emergency Stop** button on the control unit and unplug the HYPER RAPID 25 laser.

The HYPER RAPID 25 laser is an electro-magnetic device which could cause electric shock or injury if not operated according to the procedures described in this User's Guide. Make sure you carefully read and understand the safety statements contained in this section. This information shall be kept as a reference and made available to new employees working with the system. Always keep this User's Guide available near the HYPER RAPID 25 laser for all users.

The following symbols are attached to the laser head or the control unit:

Symbol	Meaning	Description
	high voltage	This symbol indicates the danger of personal injury due to dangerous electrical voltage. Refers to an imminent danger that may result in death or serious personal injury. High voltage is present in the laser head and in the control unit.
	infrared, visible, ultraviolet light	This symbol indicates that the HYPER RAPID 25 laser emits high energy laser radiation which can cause serious eye and skin injury. This radiation can be visible or invisible. Never expose unprotected eyes or skin to the direct or indirect laser light. Also light reflected from surfaces can be dangerous. **Never look into the beam.** Adequate safety precautions need to be performed.

Handling precautions

The HYPER RAPID 25 laser generates internally high voltages, high electromagnetic and high magnetic fields. Users with pacemakers and / or surgical implants shall not work beside or with the laser system without first consulting their physician.

Credit cards or any card with a magnetic stripe may be damaged by the magnetic field.

The laser radiation interacting with any material may generate dust, gases or aerosols that can be potentially harmful to human health, environment polluting, inflammable and / or even explosive. Ensure that appropriate exhaust devices are in place and make sure that they are operational and in use. The exhausted air and filters have to be cleaned and treated in accordance with environmental regulations. Waist products have to be properly disposed.

Avoid interaction of the beam with explosives, flammable or combustible materials.

Never look directly into the laser beam.

Make sure, that eyes and skin are never exposed to the laser beam radiation. A laser eye protector certified for the used wavelengths **has to be worn**, in accordance with EN207, when working on the laser beam. All national and local safety regulations are to be fulfilled. Persons working with the equipment as well as everybody in scope of the laser need to be aware and informed at any time of possible hazards.

Safety devices are never allowed to be modified or shortcut.

Disconnecting or damaging of ground conductors could lead to a dangerous situation (e.g. electrical shock). Ensure that all ground connections are effectively connected to earth.

1.4 Warranty

The warranty conditions are specified in the sales contract.

Do not open the laser head housing. An electrical interlock switch installed in the HYPER RAPID 25 laser head stops laser operation, when the cover of the protective housing is opened.

Any unauthorized modification (opening included) of the HYPER RAPID 25 laser, power supply, chiller, software or any other additional component will result in invalidity of the guarantee and service contract.

1.5 Declaration of conformity

CE The HYPER RAPID 25 is a class 4 laser in accordance with EN 60825-1 (IEC 60825-1). All local safety regulations must be satisfied (e.g. in Germany: Regulations for the avoidance of accidents BGV B2).

The HYPER RAPID 25 laser meets the US Federal Regulations of 21 CFR subchapter J part 1040.10.

Regarding this standard the HYPER RAPID 25 laser emits Class IV level of laser radiation.

The HYPER RAPID 25 laser meets the 47 CFR part 15 to control radio noise generated by Industrial, Scientific and Medical (ISM) equipment.

The HYPER RAPID 25 laser meets the requirements laid down in Council Directive 2006/95/EC relating to "Low Voltage Directive" and 2004/108/EC relating to "Electromagnetic Compatibility".

1.6 RoHS declaration of conformity

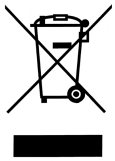
Directive 2002/95/EC of the European Union on the restriction of the use of certain hazardous substances in electrical and electronic equipment (RoHS) becomes operative as from the 1st of July, 2006. Following substances namely are involved

- Lead (Pb)
- Cadmium (Cd)
- Hexavalent chromium (CrVI)
- Polybrominated biphenyls (PBB)
- Polybrominated diphenyl ethers (PBDE)
- Mercury (Hg)

LUMERA LASER GmbH herewith declares that all of our products are manufactured RoHS conformal.

1.7 Disposal of the laser

All electrical and electronic products should be disposed of separately from the municipal waste system. Proper disposal of your old appliance prevents potential negative consequences for the environment and human health.



Components of your control unit such as the computer, monitor, keyboard, etc. which are marked with the crossed-out wheeled bin symbol are covered by the European Directive 2002/96/EC on waste electrical and electronic equipment (WEEE) of the European Parliament and the Council of January 27, 2003. These items must be disposed of via designated collection facilities appointed by government or local authorities. For more information about disposal of your old product, please contact LUMERA LASER GmbH.

1.8 Safety Labels

In the following all safety labels are described. The meaning is indicated in the list below. Most labels are located on the laser head. Refer to the schematics (laser head top view) in order to find the corresponding location. For labels, which are not located on the laser head, the appropriate unit is indicated in the list. Never remove safety labels. Lost labels have to be replaced. The customer is responsible, that persons working with or nearby the laser do have read and understood the meaning of all labels. This information needs to be available to any (involved) person any time.

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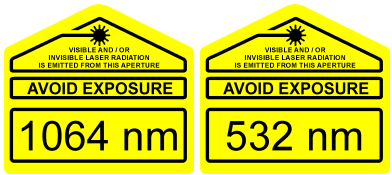
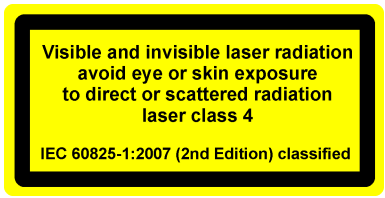
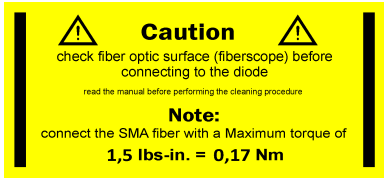
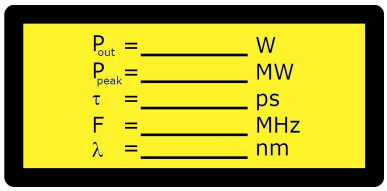
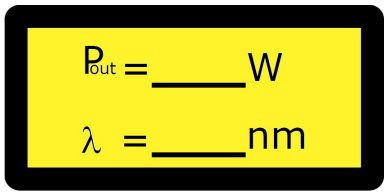
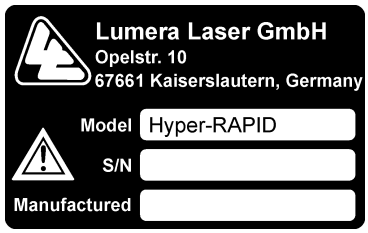
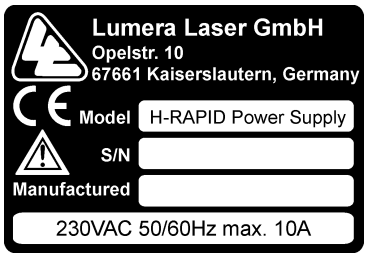
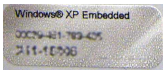
3		4	
5		6	
7		8	
9		10	

11		12	
13		14	Warranty void if seal is broken
15		16	In case of service make sure no dust is falling inside!

1	Caution: laser radiation
2	Caution, Danger: laser radiation, Class 4 / Class IV laser
3	Emergency Button (located on the power supply)
4	Laser radiation output in indicated direction with the corresponding wave-length. More than one possible, if the laser contains a frequency conversion. Also present between laser head and module (optionally when a module is ordered).
5	Caution: laser radiation, direct and indirect when cover open
6	Caution: laser radiation, avoid direct or indirect exposure
7	High Voltage present, disconnect before opening
8	Caution: laser fibers need to be clean before connecting. No mechanical stress or forces, never over-tighten, do not bend or break fibers.
9	Laser Parameters
10	Indicates output power and wavelength
11	Identification label of the laser head
12	Identification label of the power supply
13	Microsoft Windows licence (located on the power supply)
14	Seal (do not break)
15	LUMERA LASER GmbH Logo
16	Warning when changing desiccant cartridge: avoid any dust or particles

1.8.1 Location on the laser head

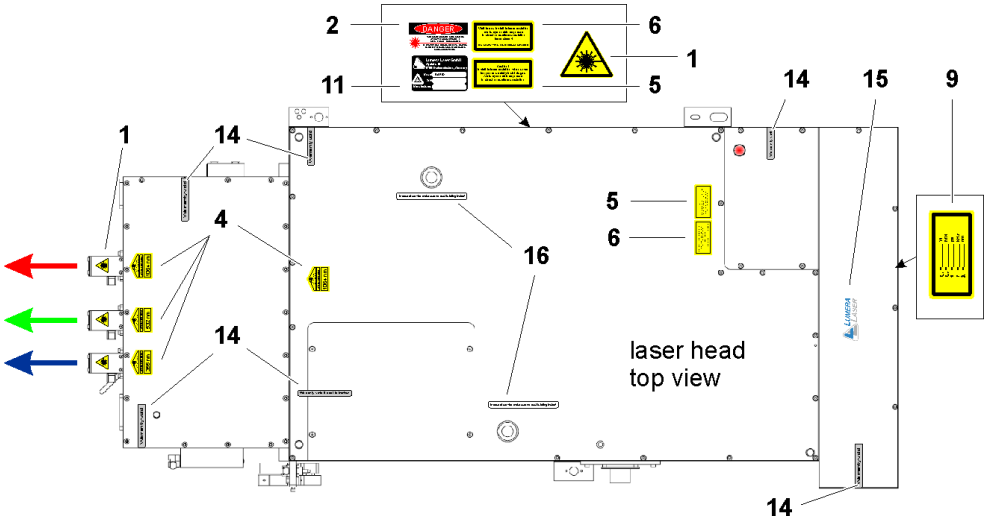


Figure 1: location of safety labels on the laser head

1.8.2 Location on the power supply

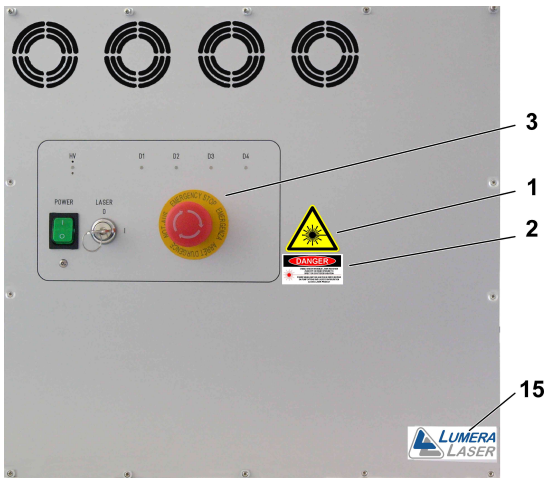


Figure 2: Front view of the control unit

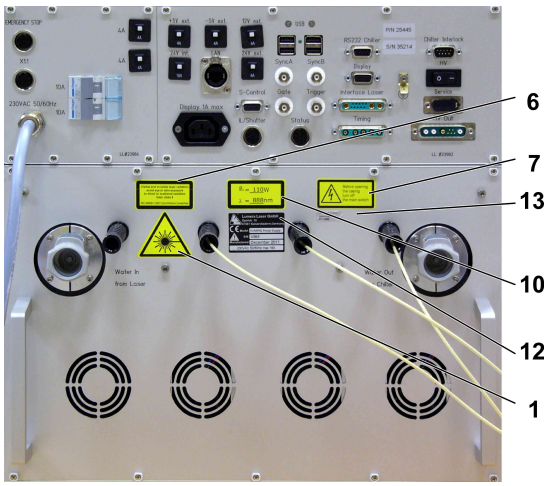


Figure 3: Rear view of the control unit

2 Installation

The HYPER RAPID 25 laser may only be installed by a service engineer of LUMERA LASER GmbH.The laser system is shipped within one or two boxes. Located on the delivery box are 3 labels indicating the safe shipment of the laser. 2 Shock Watches are positioned diagonal and one Tip Tell is located next to the Shock Watch. Inside the laser head box are two additional indicators. The condition of them should be checked directly after arrival. It is recommended to preserve all package material for the case of a further- or return transport. For this purpose there is a package instruction located on the Documentation CD.

To ensure that the HYPER RAPID 25 laser operates correctly, the installation site for the laser shall meet the requirements described in the following sections.

TIP Tell

The TIP Tell label indicates if the angle of inclination was too high during transportation. In this case the upper white area turns (partially) blue according to the inclination angle.

inclination angle ok

inclination angle was too high

Shock Watch

The Shock Watch label indicates if the succussion of the shipping crate was too high during transportation. In this case the white area in the middle turns red.

succussion ok

succussion was too high

Check the labels as soon as the crate is delivered. If you discover any irregularities:

- make photographs from the condition of the package, the labels and from inside the box if necessary.
- List all defects on the shipping documents and let the delivery company countersign.
- inform LUMERA LASER GmbH.

The crate should acclimatise for 6 to 12 hours slowly and homogeneous, afterwards it can be opened and the laser can be unpacked, refer to the unpacking instructions. Inside the crate the **data logger** is mounted to the laser head. This device records various measurements during transportation like temperature, air pressure, vibrations, etc. The data logger remains property of LUMERA LASER GmbH. Within 2 days after delivery it has to be packed into the prepared box (together with prepared delivery papers) and sent back to LUMERA LASER GmbH. Only this way conditions during transport can be made visible.

This label can be found attached to the black metallic data logger which is located on the laser head. The data logger is fixed with one (metric Allen-key) screw. Please remove the screw and send back the data logger.

2.1 Installation requirements

The HYPER RAPID 25 laser is intended for indoor use only. The laser shall be operated under clean room conditions. Ensure the security of the laser at any time. In case of doubt ask your laser safety officer (LSO).

The door to the area, in which the laser is operated, must have danger signs and warning lamps. The door may require an interlock circuit.

The laser head, as well as other components of the system, is relatively heavy. Adequate lifting devices should be used in order to prevent accidents or system damages.

- Place the HYPER RAPID 25 laser head on a level surface in the upright position. For secure transportation use the laser head handles. Any relevant security issues needs to be followed like wearing safety shoes.
- Do not place the HYPER RAPID 25 laser head next to instruments that cause vibration, electromagnetic interference, or have high inductance.
- Electrical conducted interference, created by other devices, are not allowed and need to be avoided.
- Do not place the HYPER RAPID 25 laser head in direct sunlight or close to radiators or heating devices.
- Please provide electrical connectors for the power supplies. Provided by the manufacturer are CEE 7/4 "Schuko" (alternatively C20 if ordered) connectors or blank cable ends. If the voltage deviates from 230 VAC, a transformer will be delivered. In this case one connector (valid for approx. 30 A) is necessary.
- All plugs used with the HYPER RAPID 25 laser system shall have the same phasing to prevent electronic noise generated by other instruments or by the control unit itself.
- Removing or attaching devices or any other changes as well as opening the system is not allowed. Modification would require the specific approval of LUMERA LASER.
- Use only the cables supplied with the HYPER RAPID 25 laser, refer to section "Scope of delivery" on page 18.
- Internal connectors (electrical and water-) are not allowed to be replaced, dismounted or exchanged.
- The laserhead cannot be disconnected from the control unit. The laser fibers are coupled and adjusted.
- Do not place any devices on top of the HYPER RAPID 25 laser head.

- Guarantee proper ventilation of the laser system by keeping the ventilation slots clear. Extracted air should be leaded out (fresh air should be supplied in).
- All devices have to be connected to ground. Prerequisite for a functional ground conduction is that the house internal ground circuit is also connected to ground.
- The laser system must be supplied with a voltage of 230 V. In case the house supply deviates from this voltage, a transformator (belongs to delivery) is obligatory to be used. Check if the transformator voltage complies the mains voltage before connecting. All laser system components have to be connected to the transformer.
- Observe the flow direction when connecting the chiller hoses: The coolant of the internal circuit flows from the chiller into the laserhead, into the control unit and back into the chiller (closed water loop system). All hoses are prepared with the CPC fasteners and just need to be plugged into the adequate plugs.
- Laser fibers have to be handled carefully. Do not pitch, squeezed, crack or break the fibers. Mechanical, thermal, chemical or any other forces are not allowed. Fibers need to be installed securely without the risk of any mechanical contact.

2.2 Space and power requirements

The HYPER RAPID 25 laser head needs to be placed to an appropriate position. The requirements of the environment (refer to section "Environmental requirements" on page 18) and the installation procedure needs to be observed (refer to section "Installation requirements" on page 16.

Dimensions	The dimensions of the system can be found in section "Specifications" on page 21. For detailed information concerning the fitting dimensions, construction drawings can be requested (positions of pedestal, required space, position of beam output, etc.). The values indicated in this manual can deviate from real dimensions (e.g. for non-standard constellation).
Power	The required voltage is 230 VAC / 50 Hz. From this specification deviating values are made possible by using a transformator (included in the delivery). All components need to be connected via transformator.  Any break in the electrical ground wire, whether inside or outside the laser units, or disconnection of the electrical ground connection could create a hazardous condition. Ensure that all ground connections are connected to "earth". Do not under any circumstances attempt to modify or deliberately override the safety features of this system.
Ventilation	Guarantee proper ventilation of the device by keeping the ventilation slots clear. The ventilation inlet of the control unit rack is not obstructed.
Access	A minimum clearance of about 15 inches (40 cm) must be available between the back of the laser head or the control unit rack and the wall, to allow access to the connectors. Please ensure sufficient accessibility for the Service to the laser head (top- and sideways). In case the space is critical we recommend to contact LUMERA LASER GmbH.

2.3 Environmental requirements

The HYPER RAPID 25 laser has been designed to safely operate within specifications according to CE certified technical standards at ambient room temperature between 59 °F and 80 °F (+15 °C and +27 °C), relative humidity below 60% (non-condensing) and at an altitude up to 2000 meters above sea level (850 – 1050 hP), see section "Ambient condition" on page 22.

Environmental conditions that exceed these specifications could result in instrument failure. Keep the HYPER RAPID 25 laser in a dry place. Moisture could cause malfunction. Mistreatment may damage the device, in particular the output window.

Only operate, store and ship the laser in appropriate ambient conditions.
Protect all components from grease, aerosol, dust and humidity.

2.4 Scope of delivery

The table below lists the components delivered within the HYPER RAPID 25 laser crate. The delivery can deviate from the content of this list. In order to check the completeness of all components please use the checklist coming with the delivery or the contract.

After opening, check for damage that occurred in transit. Report any visual damage to your LUMERA LASER GmbH representative.

Amount	Part
1	HYPER RAPID 25 laser head
1	HYPER RAPID 25 control unit
1	Chiller
1	Monitor, Mouse, Keyboard
1	Line cord G1544 (for the monitor)
1	HYPER RAPID 25 User's Guide, Final Report & Documation CD
2	Laser keys A126
1	DIN Interlock plug SV-60 shorted (just for testing)
1	DIN Interlock plug SV-60 for integration IL circuit
1	DIN Status plug for integration
1	DIN Emergency stop plug for integration
1	Industrial mounting kit (Allen key set)
1	Breadboard mounting kit (pedestal screws)
4	Handles L652/95 M12x30
1	Line cord for power supply
1	Line cord for chiller
1	Chiller first installation kit (water additives)

Amount	Part
1	Water change kit (hoses and CPC connectors)
2	Serial cable for chiller
1	Laser service kit (filter, water additives, cartridge)
2	Pair of gloves
1	Diodes kit in transparent. box (shortcut bridge, protective caps)
1	for Zero-Air-Generator: line cord
1	for Zero-Air-Generator: filter change kit
1	for module: beam dump / blind window
1	optional: transformer (only when mains voltage deviate from 230 V)

3 System description

The HYPER RAPID 25 is a 25 W picosecond laser. It emits short pulses with a pulse length of 7-10 ps in the infrared wavelength range (1064 nm). Optionally the infrared pulses can be frequency converted to the

- visible green spectral region (second harmonic, 532 nm)
- non visible UV region (third harmonic, 355 nm)
- non visible UV region (fourth harmonic, 266 nm)

The energy of the pulses can reach 125 µJ , the repetition rate can be chosen from 200 up to 1 MHz (or even 50 MHz in pulse groups).

The HYPER RAPID 25 laser is intended for industrial applications as well as an OEM laser source.

3.1 Specifications

The HYPER RAPID 25 laser is a diode-pumped mode-locked laser system with ultra-short pulses and high pulse energy.

3.1.1 Laser head

Instrument type	Class 4 /Class IV OEM laser
Dimensions (W x D x H)	577 x 1270 x 159 mm 22.7 x 50 x 6.3 inch
Weight	115 kg; 253 lb

3.1.2 Control unit

The control unit matches the size of a 9 U, 19" slot and can be integrated into customer systems.

Dimensions (W x D x H)	485 x 555 x 400 mm
Weight	55 kg; 121 lb
Power supply	230 VAC / 50 Hz max. 10 A (differing voltages provided by optional transformer)
Power consumption	approx. 1100 W
Noise level	<70 dB(A) (measured with power supplies & chiller)
Protection class	I (protective grounding)

3.1.3 Chiller

The chiller matches the size of a 9 U, 19" slot and can be integrated into customer systems.

Dimensions (W x D x H)	485 x 600 x 400 mm
Weight	65 kg; 143 lb
Power supply	230 VAC / 50 Hz (differing voltages provided by optional transformer).
Power consumption	approx. 1800 W
DI-water (de-ionized)	< 10 µS/cm (typically 2-5 µS/cm) [Siemens=1/Ω]
Ventilation (in case of water-air chiller)	Ensure a proper heat exchange by guaranteeing a free ventilation of fresh and "cold" air. In order to transport enough energy a straight and not obstructed air-flow must be maintained.

3.1.4 Zero-Air Generator

The Zero-Air generator matches the size of a 4 U, 19" slot and can be integrated into customer systems.

Dimensions (W x D x H)	485 x 520 x 177 mm
Weight	11 kg; 24 lb
Power supply	100 to 230 VAC , 50 / 60 Hz
Power consumption	250 W
required compressed air	2-4 bar, 0.6 Nl / min, compressed air classification 1.4.1 (refer to user manual Zero-Air generator)

The supply devices are located in the designated power supply rack unit. Generally it is possible to take each unit out of the rack. Please take cable- and hose-lengths into account. Additionally dismounting instructions might be necessary or helpful (laser fibers between the control unit and the laser head are exclusively allowed to be disconnected by LUMERA LASER Service if necessary). For further information concerning the chiller or the Zero-Air generator refer to the corresponding manual.

3.1.5 Ambient condition

During storage, transport, within an OEM-system, for the installation and during operation, the ambient conditions must be observed. Ensure reasonable transport conditions, free of major shocks, jolt or fall; protect against frost. Use original packing material for relocation.

Before unpacking the laser wait for 6 hours to allow for thermalization of all components.

Temperature allowed during transportation	+5°C to +50°C; 41°F up to 122°F
Relative humidity during transportation	10% up to 90%, no condensation
Temperature range for optimal operation	+15°C up to +27°C; 59°F up to 80°F
Relative humidity during operation	<60%, no condensation

Transportation at lower temperatures should be avoided. The whole cooling system needs to be completely drained and blown dry.

3.2 The HYPER RAPID 25 laser

The HYPER RAPID 25 laser system consists of the laser head and the rack with the control unit, the chiller and optional modules, see section "Power supply rack" on page 38.

The three main components laser head, control unit and chiller are connected electrically as well as by a closed looped water circuit.

The HYPER RAPID 25 laser is also intended for OEM industrial applications. In this case ensure the intended and proper use of the HYPER RAPID 25 laser within the machine:

- Follow the laser protection regulations
- Provide appropriate safety circuits (e.g. interlock chains). Consult your laser safety officer (LSO) for more information
- Install external laser emission indicators (e.g. warning lamps, -signs). Make sure to select colors which remain visible through the eye protection.

3.2.1 Laser head

The laser head is a rugged monolithic aluminium structure and is actively temperature controlled. It consists of a

- mode-locked oscillator (seeder laser)
- fast electro-optical modulator (pulse picker)
- amplifier chain
- optionally: a second, third, fourth harmonic generator and/or an external EOM, see section "Additional module" on page 30.

Unit	Meaning
Oscillator	The oscillator is a diode-pumped passively mode-locked solid state Nd: YVO_4 laser with a repetition rate of 50 MHz. Therefore the time between the picosecond pulses is 1/50 MHz = 20 ns. The typical pulse width is 8 ps. The oscillator is also called seeder laser.
Electro-optical modulator (EOM)	The fast electro-optical modulator selects a number of pulses out of the picosecond pulse-train to reduce the effective pulse rate. The selected pulses are amplified to gain the required energy. The electro-optical modulator is also called pulse picker.
Amplifier	To get higher energies the selected pulses are amplified in a transient amplifier chain. The amplifier uses the same gain material as the oscillator, Nd: YVO_4, which is well known for a high gain cross section leading to a very high amplification.

Located at the beam exit of the laser head module is a Brewster window (inclined to an angle around the horizontal axis). Due to this fact, the laser beam is linear s-polarised.

The HYPER RAPID 25 laser head contains various built-in interlocks and a safety shutter for mechanically closing and opening the laser output port. For further information concerning the interlock chains, see section "Control of the laser beam" on page 26.

The housing of the laser head is hermetically sealed. Ensure at all times that

- no moisture can condense on the unit
- no aggressive gases get into the case.
- the laser system is protected against frost.

Such may destroy these units.

3.2.1.1 Front view

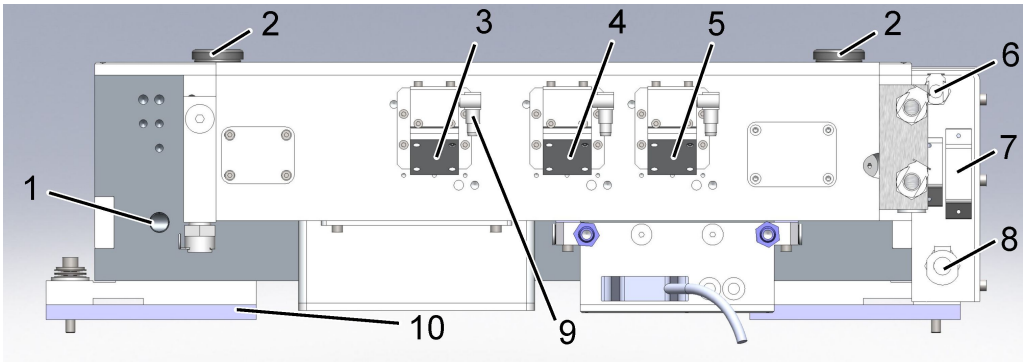


Figure 4: Front view of the laser head with adapted module

1 Connector water cooling circuit
2 Desiccant cartridge
3 Beam exit port 1064 nm
4 Beam exit port 532 nm
5 Beam exit port 355 nm
6 Connector Zero-Air Generator
7 Connector for power measurement
8 Connector water cooling circuit
9 Photo diode connector
10 Pedestal of the laser head

3.2.1.2 Rear view

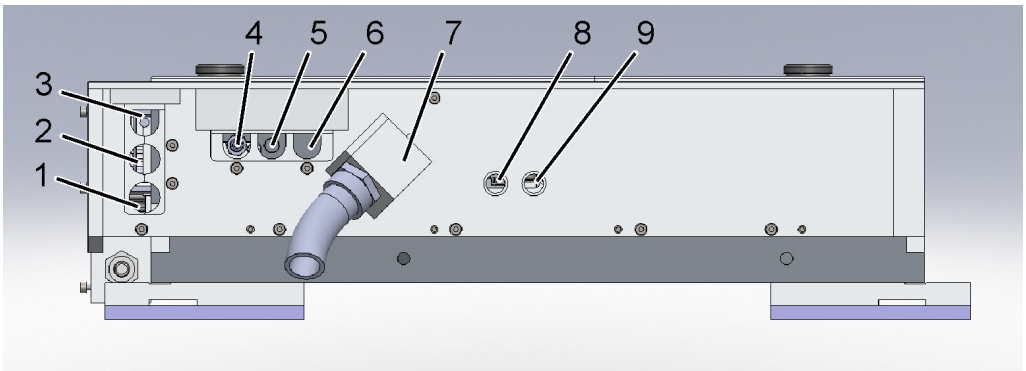


Figure 5: Rear view of the laser head

1 Chiller hose, cold water inlet from chiller
2 Chiller hose, outlet to control unit

3 High voltage power line for the pulse picker & Zero-Air hose
4 S-Control
5 HV control signals
6 Communication between control unit and laser head
7 Umbilical to the power supply
8 Monitor: oscilloscope analysis of the pulse picker
9 RFSA: spectral analysis of the seeder laser

3.2.1.3 Top view

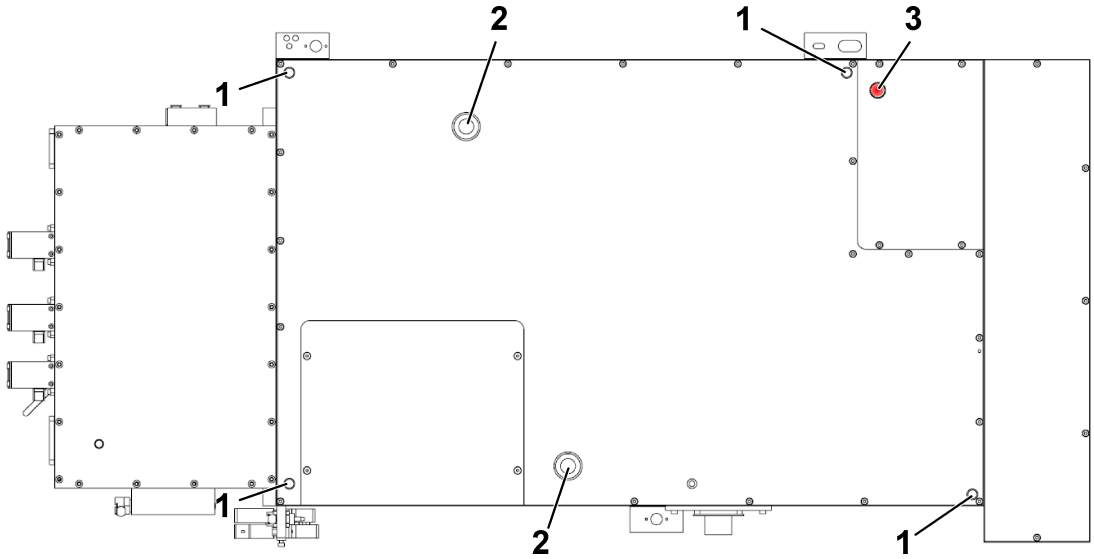


Figure 6: Top view of the laser head

1 Screw thread for transport handles
2 Desiccant cartridge to control the moisture within the laser head.
3 Lamp indicating the power status of the laser head:
- if the lamp is illuminated (red), the laser is on
- if the lamp is not illuminated, the laser is turned off.

3.2.1.4 Control of the laser beam

In order to prevent unnecessary laser radiation, there are two means to control the laser beam:

- the shutter during normal operation
- the emergency stop button in an emergency situation

Shutter

The shutter is a laser-internal safety unit. If it is closed, no laser radiation can be emitted out of the laser system.

There are several possibilities to control the shutter:

- via the software program of the control unit, see section "Main window" on page 41.
- via the external 6-pin female connector, see section "IL/Shutter connector" on page 34. This hardware based interlock overrules the software controlled one.

Via the external 8-pin female connector the status of the shutter can be read out, see section "Status connector" on page 35.

Interlock circuit

The hardware based interlock circuit is designed as a constant current loop. The constant current is approximately 10 mA. Different safety features of the laser are integrated into the interlock circuit.

Cooling	The system continuously controls the water flow, pressure, temperature, and water level of the chiller and the temperature of the assigned pumping diodes (seed laser and amplifiers). If no water flow is present within the system, the interlock gets activated.
Emergency stop button	To protect the user from dangerous laser radiation, the emergency stop button at the control unit unplugs the laser system immediately when hit. The chiller remains active.
Key switch	The key switch on the control unit also acts as an interlock and will stop laser operation immediately when turned to the off position. Thus the user can block the control unit from accidentally switching-on the laser diodes.
IL/Shutter connector	Hardware controlled, external shutter interlock. For the required integration of this safety feature consult your laser safety officer.

3.2.1.5 Pulse picking

The seeder laser within the HYPER RAPID 25 laser head generates a constant pulse train with a repetition rate of 50 MHz. A EOM (electro-optical modulator) – called pulse picker – selects single pulses out of the pulse train to reduce the effective pulse rate. The selected pulses are going to be amplified in order to gain the required energy. The unused pulses are deflected into a beam dump.

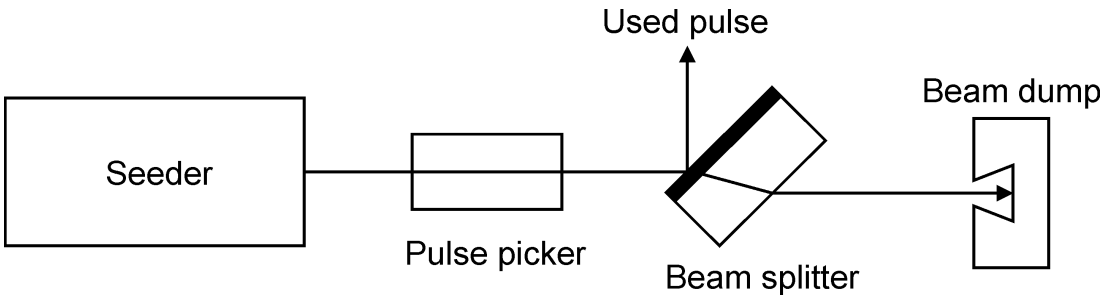


Figure 7: Principle function of pulse picker

An EOM works like an optical separator. By applying a fast high voltage (HV) signal the electrical field changes the polarisation of single pulses. A subsequent polarisation filter leads the pulse to deviated optical beam pathes according to the corresponding orientation. This way certain laser pulses can be selected and amplified.

Optionally an additional, external EOM is available. It offers further functionalities like e.g. the "first pulse suppression", refer to section "External EOM" on page 31.

Polarisation effects

The pulse-synchronous high voltage signal located at the EOM changes the polarisation orientation. A s-polarised pulse becomes p-polarised (and vice versa).

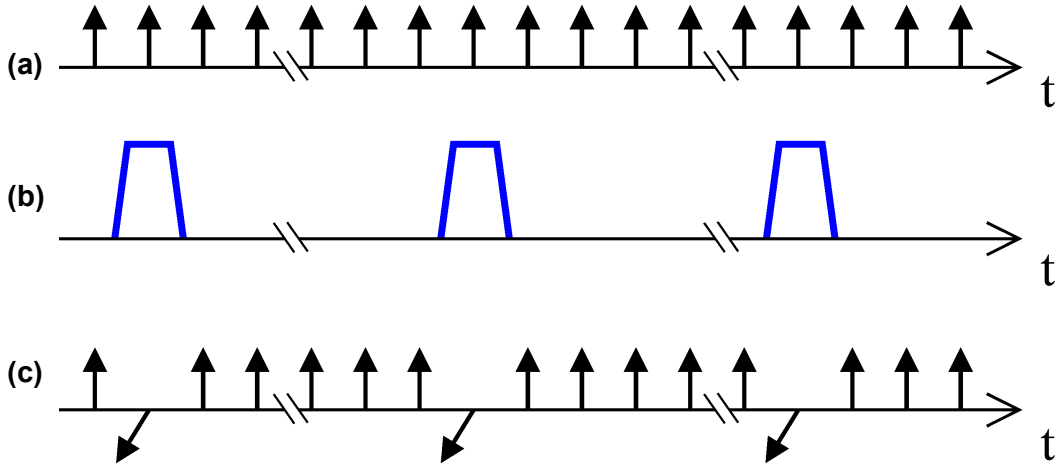


Figure 8: correlation between HV signal and polarisation

(a) polarisation direction of seeder pulse train

(b) HV signals synchronised to pulses

(c) polarisation changed for selected pulses

Function of the pulse picker

The pulse train generated in the seeder laser is displayed in the following image (d). Synchronously to the seeder pulse sequence high voltage signals are applied. They have a fast reaction time of approx. 5 ns. The repetition rate can be modulated up to 1 MHz.

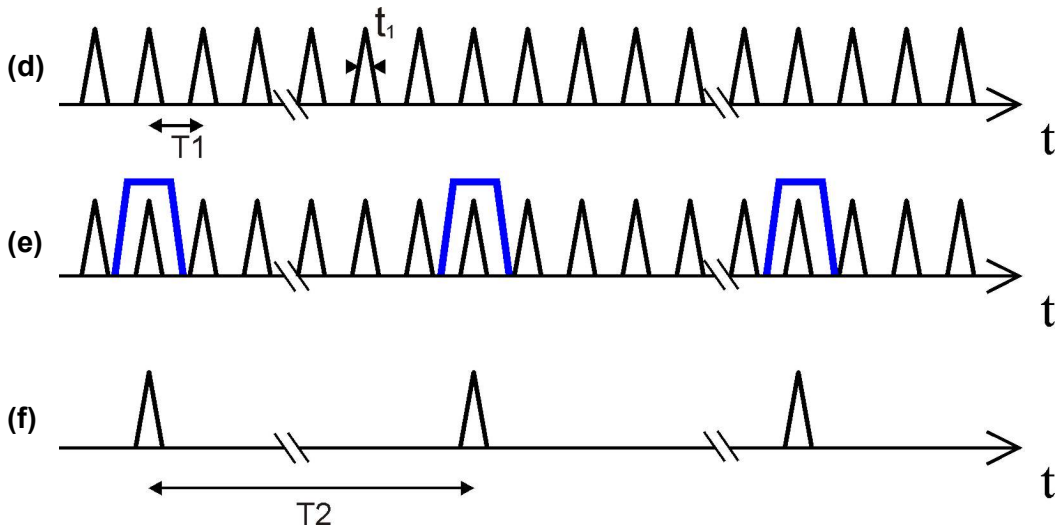


Figure 9: temporal correlation of pulses

(d) Mode-locked pulse train. Characteristic times:

t_1: pulse width of ps pulses

T1: time between seeder pulses (1/50 MHz = 20 ns)

(e) Mode-locked pulse train with HV signal

(f) Selected ps pulses with temporal distance T2 (1/repetition rate)

Burst mode

The burst mode describes the function to emit several adjacent pulses (out of the seeder pulse train). The temporal distance between pulses is 20 ns (according to the frequency of the seeder). The number of pulses in one group can be selected in the software and is limited to 10 pulses. Two pulse groups with the same or different number of pulses are possible with modus (A+B). The defined pulse group (A) is repeated with the selected repetition rate. In case of choosing (A+B) each group (A) as well as (B) is repeated with the selected repetition rate. The distance of both pulse groups are defined by the parameter **Delay group**. The temporal coherence between Delay group A and B is displayed in the diagram section "Triggering" on page 29

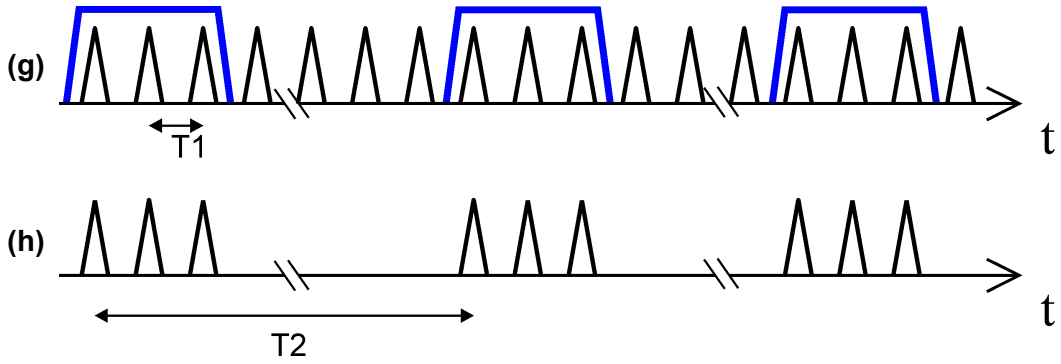


Figure 10: Selection of several pulses out of the seeder pulse train

(g) Selection of 3 pulses (bursts) (as an example)

(h) Pulse train is repeated with selected repetition rate (temporal distance T2)

Please refer to section "RepRate Control (dialog box)" on page 45 for further information concerning the software settings. Suggestions how to use these signals in the application can be found in .

3.2.1.6 Triggering

Triggers determine the control of the pulses created by the seeder laser.

Internal trigger

The laser internal pulse repetition rate is defined in the Rapid software dialog box **RepRate Control**, refer to section "RepRate Control (dialog box)" on page 45. External triggering is exclusively possible with an external EOM (optional module). The connectors Trigger and Gate at the control unit's rear side are deactivated.

Timing

The Delay times (delay group A, B) are defined in the Rapid Software and cannot be changed. The time delay between trigger and first pulse of group A is 100 ns (due to the physical run-time) plus a jitter of 0 to 40 ns, depending on the slope of the trigger signal) plus the value appointed in the Rapid Software.

The TTL Sync A and Sync B are output signals (control unit rear side) in order to synchronise external devices. They are generated approx. 0.1 µs before each pulse of the corresponding group. All temporal correlations of the signals are displayed in the image below. Further information concerning the pulse groups can be found in section "RepRate Control (dialog box)" on page 45.

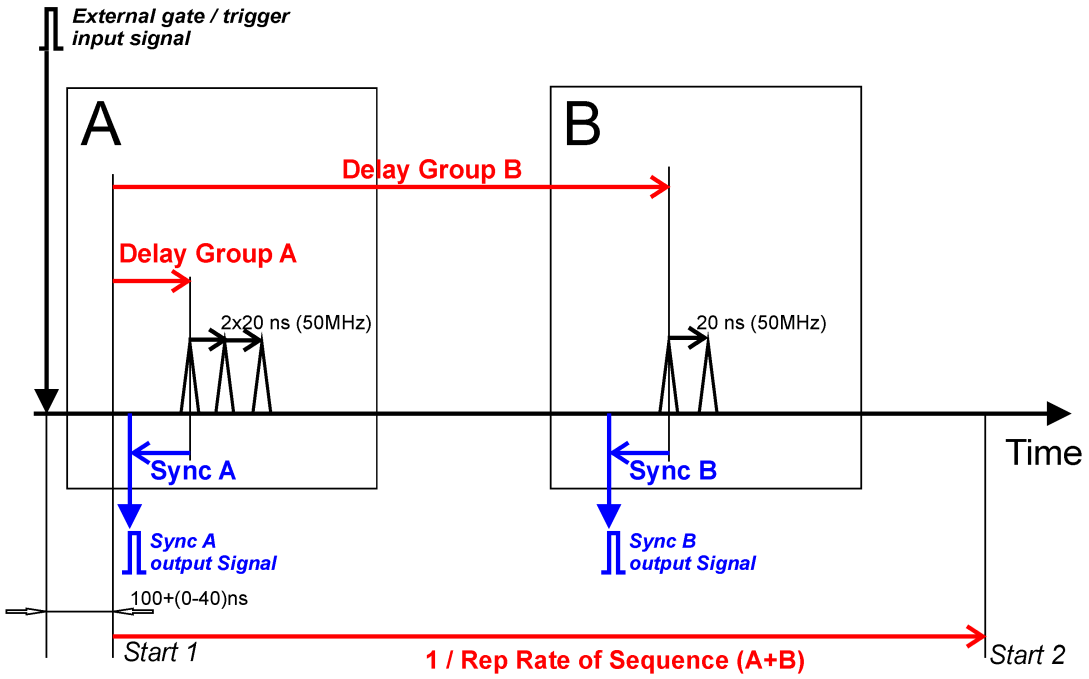


Figure 11: time correlation between Trigger and Delay signals

3.2.2 Additional module

A module is an optional component of the system attached to the laser head front and includes an optical wavelength conversion device. Furthermore the frequency conversion can be combined – and is implemented if ordered – with an external EOM (electro-optical modulator) in order to control the laser beam (switching on/off) with constant pulse energy. The module is respected during manufacturing, is individually optimised and will be delivered pre-assembled to the laser head front if ordered. Therefore the configuration needs to be ordered in advance. A subsequent integration is always possible but might interrupt the customer's workflow (it is possible that the integration cannot be done on-site).

3.2.2.1 Frequency conversion

The optical fundamental wavelength (1064 nm, invisible, IR) can be frequency converted to SHG (532 nm, visible, green). The frequency conversion into the green spectral region (Second Harmonic Generation) is generated in a nonlinear optical crystals. It is a method for the generation of laser radiation with half the wavelength of the fundamental beam. Optionally the laser can be equipped with THG (355 nm, invisible, UV) also. It is possible to switch from one wavelength to the other via Software (motorised). Due to the physical design the beam outlets (IR, SHG, THG) are spatially separated next to each other. Laser radiation – in general – (direct or indirect radiation) shall never come in contact with eyes or skin. Adequate safety provisions might be necessary. UV radiation is able of accelerating material aging.

3.2.2.2 External EOM

An EOM is a fast electro-optical switch, which can optionally be integrated into the frequency conversion module (except FHG). It is connected to and controlled by an external power supply. One important reason for using an external EOM is the need of controlling (switching on/off) the laser beam. Due to the fact that the minimum repetition rate (**Idle Frequency**) is larger than 0 Hz, the laser action needs to be internally obtained also during idling. This is a necessary laser physical process which consequently means that gating the laser (fast switching on/off during processing) explicitly can be done by an external EOM.

Another usage is the so-called "first pulse suppression". The optical energy is accumulated in the amplifier chains as long as the internal pulse picker is closed. By opening the pulse picker the internal energy gets released within the first emitted pulses. It takes a few pulses for the energy to stabilize. Consequently the first pulses lead to an uncontrolled material process, which might be undesirable. This effect has a direct physical coherence. The external EOM inhibits these over-energized first-pulses, because the laser constantly emits internally and leads the pulses to the external EOM. Here they are either transmitted or, when the EOM is closed, caught by a (water cooled) beam dump.

3.2.3 Control unit

The control unit contains the

- Power supply for the laser head and the PC monitor
- Laser pumping diodes
- Integrated PC

The control unit provides the power to operate the laser head. The integrated PC and its software program controls the laser beam. The monitor, mouse and keyboard can be plugged in to the control unit's rear side.

The control unit can be integrated into a 19" customer system. Connecting the control unit to the laser head is in charge of LUMERA LASER service technicians only. Laser fibers are not allowed to be disconnected.

3.2.3.1 Front view

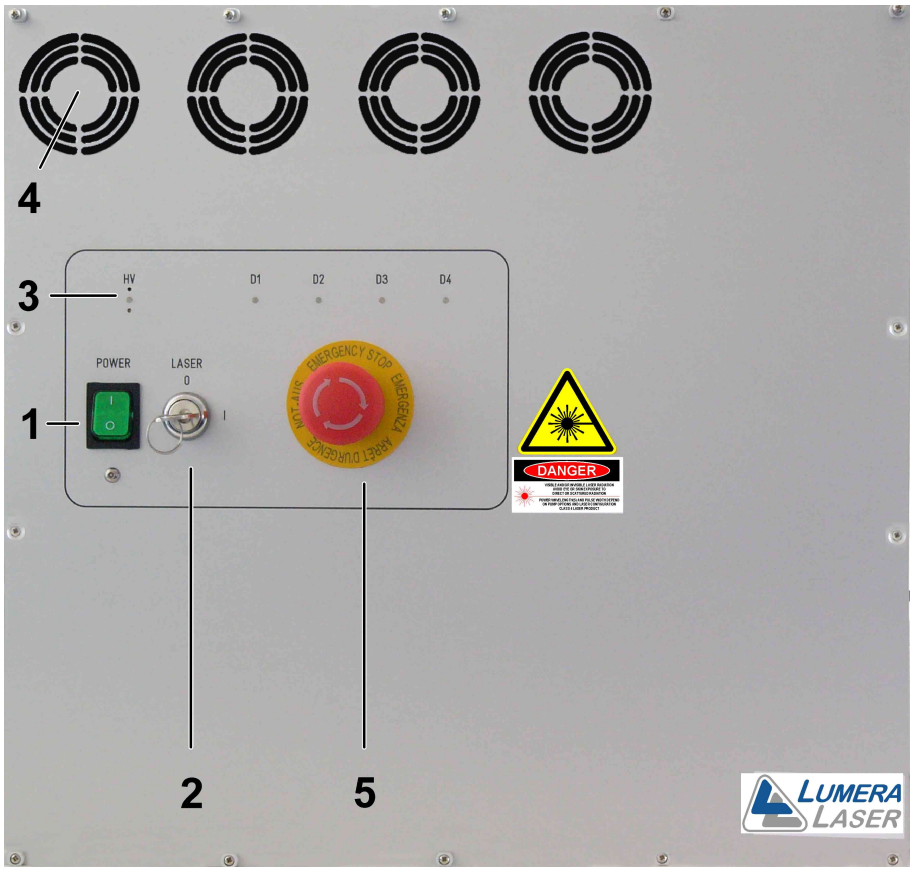


Figure 12: Front view of the control unit

1 Main power switch (On/Off); shines green, when turned on.

2 Key switch (0/I), control unit turned on is switch position I. Key removable in position 0.

3 Status LEDs for

HV High voltage connection of the pulse picker

D1 Pump diode of the seed laser

D2 Pump diode of the first amplifier

D3 Pump diode of the second amplifier

D4 Not used

The LEDs are shining during start up and are colour coded:

green	Normal operation
orange	Standby
red	Failure

4 Air inlets for fan

5 Emergency stop button; As soon as the emergency stop button is pushed, the laser system is unplugged (shutter is closed and diodes are turned off). The chiller remains active. To be able to resume operation, the emergency stop switch must be unlocked by pulling and turning the red button clockwise.

3.2.3.2 Rear view

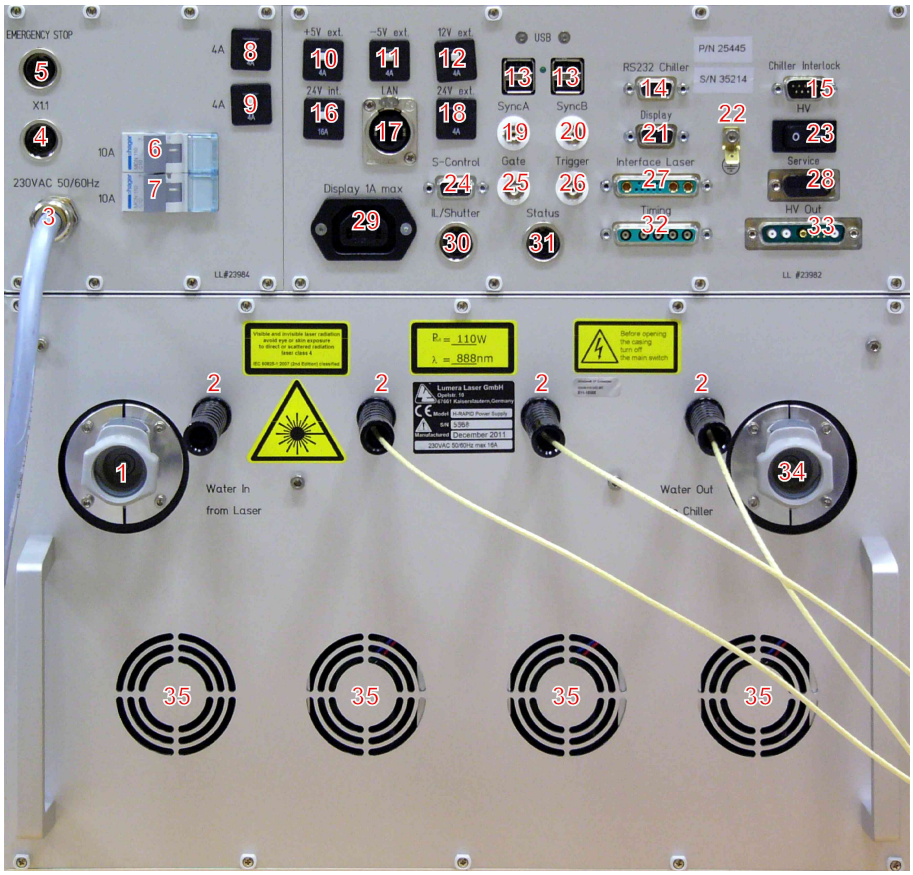


Figure 13: Rear view of the control unit

1 CPC connector water in from laser head

2 Laser diodes with fiber coupler

3 Mains power cable (230 V AC, 50-60 Hz)

4 no function

5 Output connector for emergency exit signal for a superior machine, see section "Emergency Stop" on page 36

6 Mains circuit breaker

7 Mains circuit breaker

8 Circuit breaker (4 A)

9 Circuit breaker (4 A)

10 Circuit breaker +5 V

11 Circuit breaker -5 V

12 Circuit breaker 12 V

13 USB connectors of the internal computer

14 Sub-D connector – RS-232 chiller, communication interface to chiller

15 Chiller interlock connector

16 Circuit breaker 24 V

17 Ethernet connector

18 Circuit breaker 24 V

19 Sync A: output TTL signal approx. 0.1 µs before pulse group A

20 Sync B: output TTL signal approx. 0.1 µs before pulse group B

21 Monitor connector (VGA)

22 Ground connection for the rack

23 Service switch for HV power supply

24 Connector to S-Control

25 no function

26 no function

27 Connector for laser head interface cable (inlcuding ground connection of the laser head)

28 Sub-D service connector (HV). LUMERA LASER service only

29 Power connection for the monitor

30 Output connector for shutter signal for a superior machine, see section "IL/Shutter connector" on page 34

31 Status connector (potential-free), provides laser status signals, see section "Status connector" on page 35

32 Timing - connector for HV switch in the laser head

33 Connector for HV cable (high voltage)

34 CPC connector water out to chiller

35 Air outlet for fan

3.2.3.3 IL/Shutter connector

The IL/Shutter connector is an interface on the back of the control unit, that can be used to input a shutter activating event to the laser head. The shutter activating event can be relevant in case, e.g. the laser system is emitting beams and the door of the room or the machine, in which the laser system resides, is opened.

The IL/Shutter connector is a 6-pin female connector.

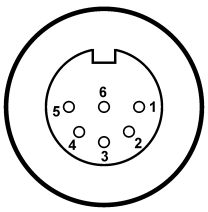


Figure 14: Interlock/Shutter connector (female)

Pin	Setting
1	Plus (+) external interlock switch
2	Shutter safety switch
3	Shutter safety switch
4	Minus (-) external interlock switch
5	Shutter push button

Pin	Setting
6	Shutter push button

Interlock switch

Pin 1 together with pin 4 can be used to realize an external interlock. Opening this chain causes a shut down of the laser system. When an active circuit is connected the polarity needs to be regarded (refer to the table). Attaching a passive switch the polarity is not relevant.

Please take into account that the shutter is only able to be opened when the safety chain is closed. For testing purposes there is a short-cut connector (dummy) included in delivery. This one is not allowed to be used for normal operation and has to be replaced by a real safety interlock circuit.

Shutter safety switch

Pins 2 and 3: As long as these contacts are connected, the shutter can be operated. When these pins are not connected, the shutter cannot be opened or closes automatically if open. The inputs are galvanically separated.

Shutter push button

When Pin 5 and Pin 6 get temporary connected (e.g. with a push button) the shutter opens/closes. This function complies with a click of the **Shutter** in the Rapid Software. The pins are galvanically separated (potential-free).

Connection

In order to implement the Interlock/Shutter circuit the adequate connector (male plug, included in delivery) can be used. The design and implementation remains the responsibility of the customer. For further information concerning regulations of interlock chains we refer to e.g. EN11553-1 and EN60825-1. Please understand this as a recommendation without warranty of completeness (national and local rules can be location dependent).

3.2.3.4 Status connector

The Status connector is an interface on the back of the control unit, that can be used to output the present state of the laser system. The status can be relevant in case, e.g. the laser system is assembled into a machine.

The Status connector is an 8-pin female connector. The outputs are galvanically decoupled. The maximum allowed voltage at the connectors is 24 V / 0.5 A.

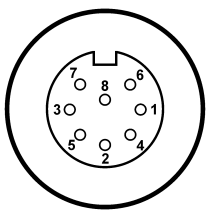


Figure 15: status connector (female)

Pin	Setting
1	Relay contact **diodes on/off**: is internally closed with pin 6, when the laser diodes are switched on (LED on control unit front side is illuminated green)

Pin	Setting
2	Relay contact **shutter position**: is internally closed with pin 4, when the shutter is open
3	Relay contact **interlock error**: is internally closed with pin 5, when an interlock error appeared (interlock circuit interrupted).
4	Refer to pin 2
5	Refer to pin 3
6	Refer to pin 1
7	No function
8	No function

For using the Status connector, a cable with a matching male connector is delivered. The implementation and usage of the signals remains the responsibility of the customer.

3.2.3.5 Emergency Stop

The socket **Emergency Stop** is located at the rear side of the control unit and includes 2 coupled emergency Interlock signals (output). As soon as the Emergency Switch is pressed (control unit front side), both circuits open. This way one or two external interlock loops can be interrupted. The connection is designed for 230 V, 3 A.

The socket is a 4 pin plug. The circuits are potential free (galvanically isolated). The corresponding connector belongs to the delivery.

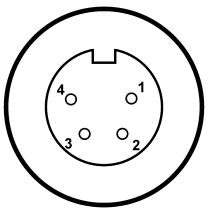


Figure 16: emergency stop socket (female)

Pin	Description
1	Relay contact is internally closed with pin 2, as long as emergency switch (front side) is not activated.
2	refer to pin 1
3	Relay contact is internally closed with pin 4, as long as emergency switch (front side) is not activated.
4	refer to pin 3

3.2.4 Chiller

In order to operate the laser a chiller is necessary. LUMERA LASER GmbH offers two different chiller types:

Water to Air Chiller	This chiller only needs an adequate power connection. In addition it must be ensured that the discharged air of the cooler is conducted.
Water to Water Chiller	This chiller needs an adequate power connection and an additional water circuit (primary circuit), which is connected to both CPC connectors at the rear side of the chiller. The water circulation needs to be supplied with 5 l/min volume minimum. The cooler switches the primary water via a valve.

In case the voltage deviates from 230 V, an external transformer is necessary in order to operate the chiller, the control unit and optionally additional devices. In this case the chiller is not allowed to be powered without the transformer.

Ensure the correct mains voltage.

The water flows from the chiller (blue label, chiller rear side) into the laser head, then through the control unit cooling the laser diodes and back into the chiller (red label, chiller rear side). The water circuit is visible in the image below. The red markings define positions where the hoses can be unplugged (CPC fasteners).

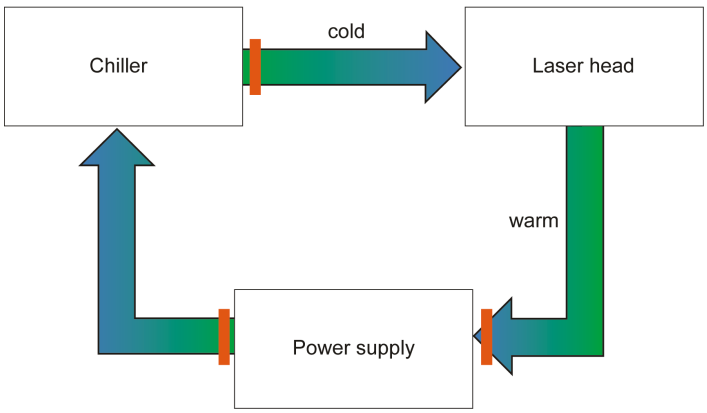


Figure 17: Water circuit of the HYPER RAPID 25 laser

The chiller is switched on automatically when the HYPER RAPID 25 software is started. The temperature of the chiller is also set or changed via the laser software.

Initially stabilising the water temperature can take approximately 20 min.

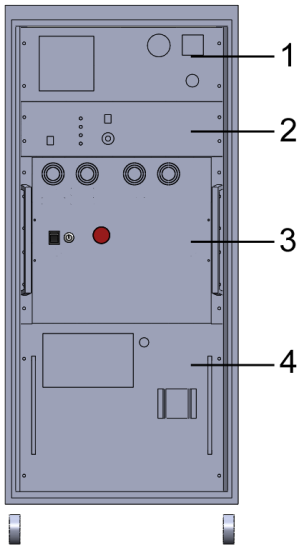
Verify the coolant in the chiller is at a proper level. Preventive maintenance for the chiller (changing water and filter at the same time) is mandatory at regular intervals, every 6 months, see section "Maintaining the chiller" on page 60.

In order to ensure enough heat exchange (in case of a water to air system) make sure that there is sufficient amount of space behind the chiller (>0.5 m, 20 inches). Also the air circulation / ventilation and fresh air supply should not be constricted.

For more information please refer to the chiller manual. Coolant fluid can be corrosive. Adequate protection is necessary.

3.2.5 Power supply rack

According to the optionally ordered modules, the rack will include the corresponding supply- and control unit. A Zero-Air generator is necessary in case of a frequency conversion module. The external EOM is supplied by an EOM controller.



1 Zero-Air Generator

2 EOM controller (in case an external EOM is ordered).

3 Control unit for the laser head

4 Chiller

Figure 18: Power supply rack

3.2.5.1 Zero-Air Generator

The Zero-Air-Generator resides in the rack of the control unit, if you have ordered a frequency conversion module (SHG, THG, FHG). Via the Zero-Air-Generator you purge the laser head with cleaned air to dispose of hydro carbons. For this the air is heated in the Zero-Air-Generator up to 450°C and cooled down before purging the laser head.

The Zero-Air-Generator needs about 30 minutes to warm up to 450°C operating temperature. Additionally the Zero-Air-Generator needs clean compressed air of class 1.4.1 with an inlet pressure of 2 to 4 bar and an airflow capacity of 0.6 norm-litre per minute. For more information, see the manual of the Zero-Air-Generator.

For more information refer to the Zero-Air-Generator manual.

Front view

Figure 19: Zero-Air-Generator front view

Flow controller (Nl/min)	Air flow measurement
Temp controller	Present temperature within the Zero-Air-Generator
Power on/off	Main power switch of the device

Rear view

Figure 20: Zero-Air-Generator rear view

Alarm	Optional: alarm connector: feedback about temperature status for an external control.
Power in fuses	Fuses for the power input
Air inlet	Input for compressed air.
Air outlet	Output for cleaned air into the laser head.

4 Rapid Control software

The HYPER RAPID 25 software is pre-installed on the integrated computer of the control unit. In order to control the laser system with the integrated PC, a keyboard and mouse can be attached to the USB ports on the rear side of the control unit.

The laser control software can act directly via "graphical user interface (GUI) or over a client / server connection via an Ethernet cable. For this a DLL (dynamic link library) exists, see section "Controlling the laser from an external PC" on page 50.

4.1 Main window

The Rapid Control software starts with the main window in which the major laser settings are displayed or reachable over the menu. The menu contains the entries **File**, **Tools**, **Service**, **Test** and **?**. The functions are described in this chapter.

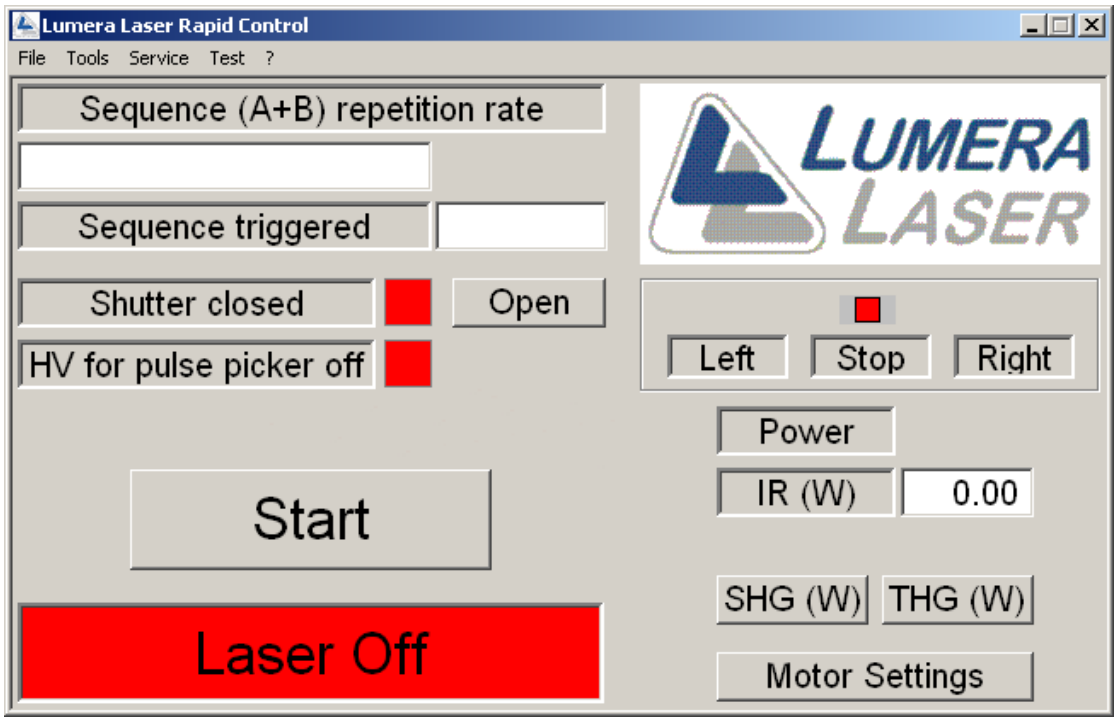


Figure 21: Laser control software: main window

Sequence (A+B) repetition rate

Displays the repetition rate. In order to change these settings, see section "RepRate Control (dialog box)" on page 45.

Sequence triggered

Internal: The laser is triggered internally. In order to trigger externally an external EOM is required.

Shutter open/closed

Displays the present state of the shutter. The **Close**/**Open** button toggles between both states. Each state is colour coded:

Red	The shutter is closed, no laser beam is emitted.
Green	The shutter is open and the laser beam is emitted.

HV for pulse picker on/off

Displays the present state of the high voltage drives for the pulse picker. The **On**/**Off** button toggles between both states. Each state is colour coded

Red	High voltage for the pulse picker is off, the laser is not ready to work.
Green	High voltage for the pulse picker is on, the laser is ready to work.

Left, Stop, Right

Displays the variable attenuator position. The red box above **Stop** symbolises that the attenuator is standing still. Any moving action will be displayed with a green box above the direction field. The motor position will be saved when the laser gets turned off and reloaded during startup.

Power

Displays the optical power for the corresponding wavelength (IR,SHG,, optional THG). In order to change the power, open the dialog **Motor Settings**. When the laser is turned on the last position of the variable attenuator will be relocated. Please note that the internal power measurement has an accuracy of 5%. Measuring more exact can only be done externally by the customer.

IR (W), SHG (W), THG (W)

This icon located below the power display allows to switch between available frequencies. The choice depends on the ordered frequency conversion module. Furthermore the precondition "software selectable" is necessary.

Start/Stop

Switch for turning on/off the laser.

Laser On/Off

Displays the present laser state.

Red	The laser is off and not ready for work.
Green	The laser is turned on and ready for work.

Motor Settings

Opens the **Motor Settings** dialog box, see section "Motor Settings (dialog box)" on page 42.

4.1.1 Motor Settings (dialog box)

The **Motor Settings** dialog box displays the present position of the attenuator. The attenuator controls the optical power of the laser system. In order to keep the beam parameters most constant, the laser runs with constant current and maximum power. Decreasing the beam power takes place by changing the position of the so-called variable attenuator. The functions are described in this chapter.

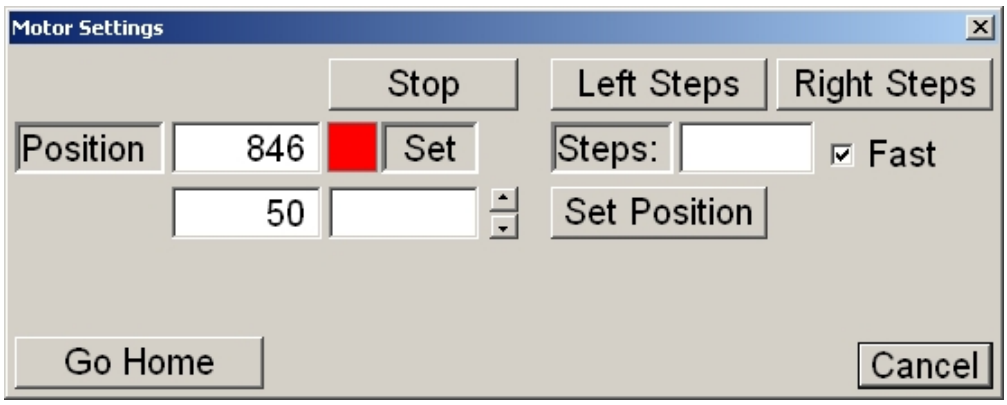


Figure 22: Motor Settings dialog box

Left Steps/Right Steps

Moves the motor counter clockwise / clockwise with the in **Steps** defined number of steps. **Fast** enables the movement with increased speed.

Position

Displays the present position of the attenuator. The range is between 0 and 1692 steps. (In case a high resolution attenuator was ordered the range is between 0 and 10800). The box on the right indicates a movement (green) of the attenuator or red when the attenuator does not move. Below this field the position is displayed in percent. The empty area on the right enables the entry of a requested value in percent (0-100%). It also can be modified by clicking the arrow up/down. The impact on the power is not linear. Entering a value (in steps or in percent) needs to be activated with **Set Position**. With **Stop** an executed movement can be interrupted. An actual position is going to be saved when the system gets turned off and reallocated after turning on the laser.

Stop

Interrupts the active movement.

Go Home

Moves the attenuator to the default power position.

Cancel

Cancels the dialog and closes the window.

4.2 File menu

The **File** menu contains the following commands:

Open

Opens and loads individual settings for the repetition rate control, see section "RepRate Control (dialog box)" on page 45.

Save Permanent

Allows to save the present settings of the repetition rate control in the backup folder `C:/Rapid/Rapid_backup`. The previous parameter set will be overwritten.

Restore

Restores the previously saved settings of the repetition rate control.

Quit
Closes the Rapid Control software.

4.3 Tools menu

The **Tools** menu contains the following commands:

Laser Data
Opens the **Laser Data** dialog box, see section "Laser Data (dialog box)" on page 44.

RepRate Control
Opens the **RepRate Control** dialog box, see section "RepRate Control (dialog box)" on page 45.

Seeder Laser Control
Opens the **Seeder Laser Control** dialog box , see section "Seeder Laser Control (dialog box)" on page 46.

Amplifier Laser Control
Opens the corresponding **Amplifier Laser Control** dialog box, see section "Amplifier Laser Control (dialog box)" on page 47.

4.3.1 Laser Data (dialog box)

The **Laser Data** dialog box displays the status information of the HYPER RAPID 25 laser. The displayed information are dependent on the system constellation.

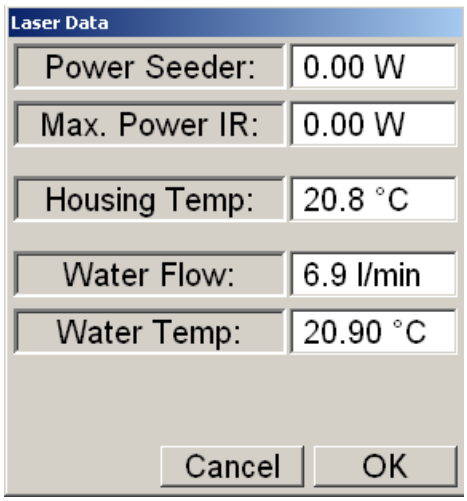


Figure 23: Laser data dialog box

Power Seeder
Present power of the seeder laser (oscillator).

Power Amplifier1
Present power of the first amplifier measured by internal photo diodes.

Power Amplifier2
Present power of the second amplifier measured by internal photo diodes.

Power Amplifier3
Present power of the third amplifier measured by internal photo diodes.

Housing Temp
Present temperature of the laser head housing. The preset temperature is +21 °C.

Water Flow
Present flow rate of the chiller.

Water Temp
Present temperature of the chiller.

Air Flow
Present volume of air coming from the Zero-Air Generator , see section "Zero-Air Generator" on page 38.

Power IR Laser
Present IR power; measured by internal photo diodes.

4.3.2 RepRate Control (dialog box)

In the **RepRate Control** dialog box you can configure the pulse repetition frequency. Generally two pulse groups (A and B) can be defined. They are combined into one pulse sequence, also refer to section "Pulse picking" on page 27. In order to get a Repetition rate of e.g. 500 kHz you can choose the entry 500 kHz = 250kHz(A+B). The present settings can be saved with **File/Save**. When the HYPER RAPID 25 laser is started, the last saved settings are reloaded. In the following you can get a description of all functions:

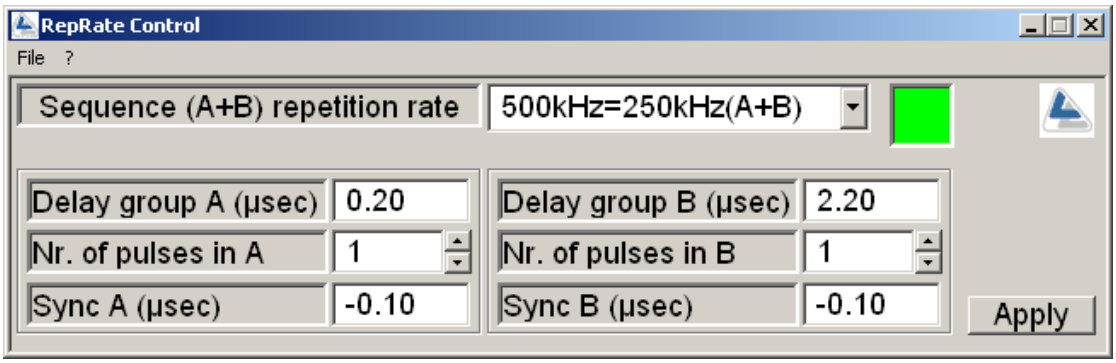


Figure 24: RepRate Control dialog box

The dialog box contains the menu entries **File** and **?**.

The **File** menu contains the following commands:

Save
Saves the present settings of the repetition rate control. These settings are loaded by the next startup of the Rapid Control software.

Hide
Minimizes the dialog box to the system tray without closing the window.

The **?** menu contains the **Info about RepRate Control** command that opens a dialog box, in which the version of the repetition rate control software is displayed. Close the dialog box with **OK**.

The dialog box offers the following options:

Sequence (A+B) repetition rate
List of possible, selectable repetition rates (200 to 1000 kHz). the coloured box next to the area indicates the functionality of the trigger:

red	trigger is not ready or external trigger does not get a signal
green	trigger is operational.

Delay group A/B (µsec)
The delay times are production-related values which cannot be modified.

Nr. of pulses in A/B
Amount of pulses in group A/B. You can select a maximum of 10 pulses per pulse group. The groups are generated and emitted after each other. Example: group A: 3 pulses, group B: 5 pulses. The pulse sequence is: 3 5…3 5…3 5…. The pulse sequences are emitted with the repetition rate defined in the dialog. The frequency of adjacent pulses is 50 MHz, according to the frequency of the seeder laser.

Synch A/B (µsec)
Value is production-related and cannot be modified (output signal relative to the pulse group, refer to section "Control unit" on page 31).

Apply
Changing values need to be confirmed with pressing **Apply**.

4.3.3 Seeder Laser Control (dialog box)

The **Seeder Laser Control** dialog box contains the information concerning the seeder laser described in this chapter. Only the LUMERA LASER Service is able to adjust the settings.

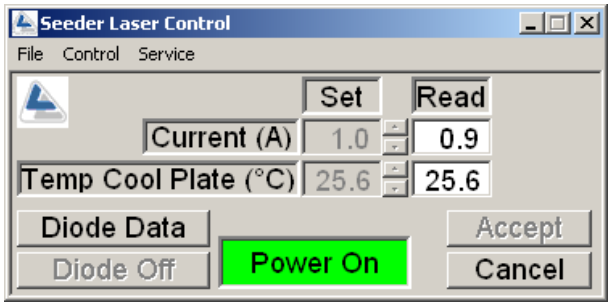


Figure 25: Seeder Laser Control dialog box

The dialog box has a menu bar with the entries **File** and **Control**.

The **File** menu contains the command **Exit**, that closes the dialog box.

The **Control** menu contains the following commands:

Diode Data
Opens the **Diode Data** window, that displays the present settings for the related diode, see section "Diode Data window" on page 47.

Diode On
Toggles between the diode states. Each state is colour coded:

Red	The diode is turned off.
Green	The diode is turned on.

Current (A)
Displays the present current.

Temp (°C)
Displays the present temperature in degrees Celsius. The temperature values are colour coded:

white	The temperature is in normal range.
blue	The temperature is too low. Wait until the laser is on working temperature.
red	The temperature is too high. Wait until the laser is cooled down and on working temperature.

Power On/Off
Displays the diode laser state.

4.3.4 Amplifier Laser Control (dialog box)

The **Amplifier Laser Control** dialog box displays the same information like the dialog box for the Seeder Laser Control (refer to the chapter before) concerning the corresponding amplifier diodes. Only the service personnel of LUMERA LASER GmbH can adjust the settings.

4.3.5 Diode Data window

The **Diode Data** output window displays the present settings for the selected diode (seed laser or amplifier). It is reachable by choosing **Control** in the corresponding **Laser Control** dialog box.

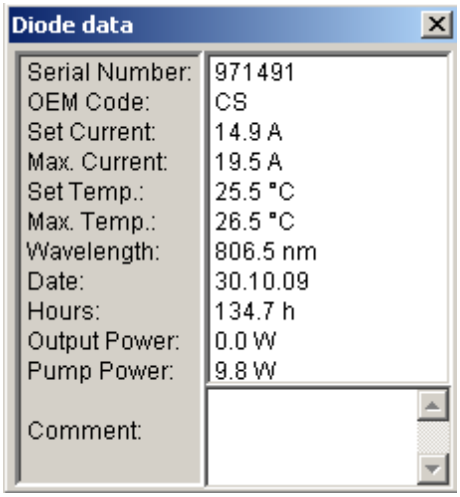


Figure 26: Diode Data output window

Serial Number
Serial Number of the selected diode.

OEM Code
Service information.

Set Current
Requested current of the selected diode.

Max Current
Maximum current for the selected diode.

Set Temp
Requested temperature of the selected diode.

Max Temp
Maximum temperature for the selected diode.

Wavelength
Present wavelength.

Date
Date when the diode was mounted into the laser.

Hours
Operating hours.

Output Power
Present power of the selected diode.

Pump Power
Set value of the selected diode.

Comment
Comment.

4.4 Service menu

The **Service** menu contains the following commands:

Enter Service Password
Opens the **Service Password** dialog box in which you can enter the service password. The service password enables advanced access for the LUMERA LASER Service personnel.

Chiller Maintenance
Opens the **Chiller Maintenance** dialog box. After changing coolant and filter (recommendation to do both at the same time) you can reset the time counter by clicking the dialog **Chiller Water Changed**. This action needs to be confirmed in a second dialog. For further information concerning the maintenance refer to section "Maintaining the chiller" on page 60. Resetting the counter can be checked and is described in the section "? menu" on page 49.

4.5 Test menu

The **Test** menu contains the following command:

Set Test Params

Opens the **Set Test Parameters** dialog box in which you can set a time value to define intervals of saving laser specific logging parameters. The default value is 600 seconds. The button **Disable** deactivates the recording (**Enable** activates it). The Logging file is called `xxxx_Data.lll` (xxxx is replaced by the serial number of the laser) and can be found in the directory `C:/Rapid/Rapid_Main/Main_Program`. Opening the file is possible with any editor, preferably with a table calculation program.

4.6 ? menu

The **?** menu contains the following commands:

Info about Rapid Control

Opens the **Info about Rapid Control** dialog box, in which versioning information about the software components is displayed.

Create Status report

Creates a status report file with actual information and settings of the laser and saves it on the desktop (Windows start-window) of the system internal computer.

We recommend to create a status report file each month and send it to LUMERA LASER GmbH: service@lumera-laser.com.

Maintenance Information

Opens the maintenance information window, in which the following operation counters are displayed:

- number of days, after which a coolant & filter change is necessary (count-down, starting at 183 days).
- operating hours of the Seeder diode.
- operating hours of the amplifier diodes.

4.7 Performance monitor

The Rapid Control software monitors (if necessary) the condition of the HYPER RAPID 25 laser via a message box:

Status	Description
start-up	Thermalisation can take up to 30 minutes (depending on the environmental conditions) after turning on the HYPER RAPID 25 laser system.
OK	The HYPER RAPID 25 laser starts without any messages.
warning	A dialog window shows the corresponding warning. It has to be regarded and a maintenance might be necessary to schedule (e.g. performing S-Control). This message appears once during start-up.

Status	Description
error	A dialog windows shows the corresponding error. It is required to remove the cause of error. A maintenance cycle (e.g. S-Control) has to be performed. Alternatively LUMERA LASER Service can be contacted. This message permanently appears and shall not be ignored, see section "Software maintenance" on page 64.
shut down	The laser does not produce enough power or has another problem which causes a complete shut-down of the laser. In this case contact LUMERA LASER Service.

4.8 Controlling the laser from an external PC

Beside the Rapid Control software on the control unit the HYPER RAPID 25 laser can also be controlled via a DLL. If the HYPER RAPID 25 laser is part of a machine, it thus can be controlled via network.

For controlling the HYPER RAPID 25 laser from an external PC a server application within the control unit and a client application on the external PC are necessary to control the laser system:

- On the control unit the server application `LL_Server.exe` is necessary, which receives and converts the instructions over the LAN connection. After the server application is started it checks for a connection with the client application over the network. If you want to control the HYPER RAPID 25 laser via an external PC, it is recommended to start the server application automatically via autostart.
- On the external PC a client application receives and transfers the instructions to the server. LUMERA LASER GmbH provides a client DLL for the network access, which has to be installed on the external PC. The `RapidClient.dll` makes functions available to connect with the control unit and for the operation of the HYPER RAPID 25 laser. Both computer have to be connected via cross-link Ethernet network cable. All commands are described in the "Rapid DLL Specification" manual located on the documentation CD.

When using a firewall on the external PC, ensure that the specified communication port is open. This communication port is set in the `ConfigN.ll2` configuration file for the server and the client application.

How to install and configure the client application on the external PC is described in section "Configure the client application on the external PC" on page 51. After the configuration you can test the connection with the `Rapid_DLLtest.exe` program, see section "Testing the client application" on page 51. Further information can be found in section "External control" on page 56.

4.8.1 Installation of the Server application

The server application is already installed on the integrated computer of the control unit (in case this option was ordered). In case the option delivered later, the installation procedure described in this chapter needs to be followed. All program files located on the delivered CD needs to be copied with a USB stick or via local network. Setting up a network connection depends on the operation system and might deviate from this procedure.

1. Copy the folder `Rapid_Server` into `C:\Rapid\` on the integrated PC.
2. Open the file `C:\Rapid\Rapid_Server\ConfigN.ll2` with notepad (or any other editor).
3. Enter the number of the port, server and client are supposed to communicate over. This port must be identical for both applications.
4. Save and close the file `ConfigN.ll2`.
5. Open **Control Panel**, in order to setup a network connection.
6. Choose **network connection / new connection**.
7. Choose **setup an advanced connection / allow incoming connections**.
8. In **Devices for incoming connections** select the appropriate COM port.
9. Select **Incoming VPN connections** and enter the appropriate user ID (or install a new user in **User access**).
10. Then select **network protocol / TCP/IP / properties**.
11. **enter TCP/IP address**. Enter the IP address of the Server computer in **from** and **to**. (The address can be found in properties of LAN connections / Internetprotocoll (TCP / IP)).
12. Confirm setup with **OK**.
13. Include the file `C:\Rapid\Rapid_Server\LL_Server.exe` into the autostart procedure of Windows.

4.8.2 Configure the client application on the external PC

1. Copy the `Rapid_Client` directory from the CD to the `Rapid` directory of the external PC. Alternatively you also can choose a different directory name as long as all client files are stored in the same folder.
2. Open the `ConfigN.ll2` file in notepad (or any editor).
3. Enter the port number, server and client application are supposed to communicate through. This is the same port number which was entered on the server.
4. Enter the IP address of the control unit.
5. Save and close file `ConfigN.ll2`.

4.8.3 Testing the client application

You can test the client application on the external PC with the `Rapid_DLLTest.exe` test program. This program resides in the `C:\Rapid\Rapid_Client` directory (and in the backup folder of the delivered documentation-CD). We recommend to start the program on the client computer in order to test the network connection as well as the transmission of commands.

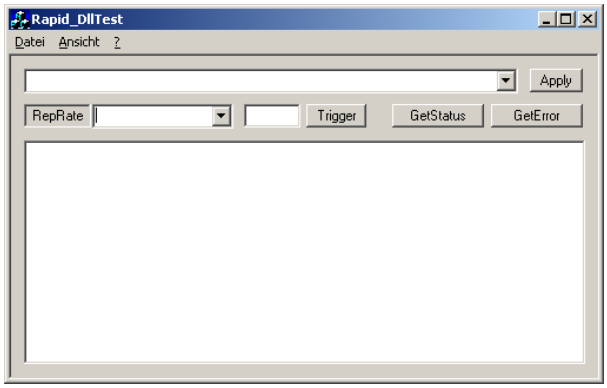


Figure 27: Rapid_DLLTest program

Choose a command from the drop-down list and press **Apply** in order to activate the function.

GetStatus delivers the status of the laser.

GetError delivers a text string, which describes the corresponding error in case of appearance. If a command was sent and created an error, the feedback is displayed automatically in the description area of the DLLTest program. We recommend to program an interface in a similar order of commands: In case a command creates an error, the return value will be -1 (also refer to "DLL specifications"). Then the error should be requested by the command "ErrorGet" and can be displayed to the user.

RepRate: By choosing the command **Pulse Frequencies Get** (out of the drop-down list above RepRate) a list of all possible repetition frequencies appears right next to the RepRate entry. On the other hand using the command **Pulse Frequency Get** will display the actually set repetition rate.
In order to change the selected repetition rate, choose an entry out of the drop down list, choose the command **Pulse Frequency Set** and press **Apply**.

In order to transmit a parameter please use the field right next to the RepRate drop down window. For example **IR Power Level Set** expects the delivery of the power in Watt.

The entries **Datei** and **Ansicht** in the menu do not have a function.

The definition of the trigger expects the delivery of several parameters. In order to simplify this procedure, open the dialog **Trigger**.

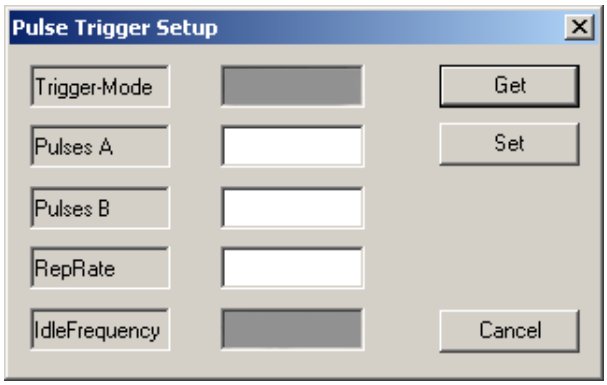


Figure 28: Pulse Trigger Setup dialog

Parameters you find in here correspond with the ones from the commands **Pulse Trigger Setup Set** and **Pulse Trigger Setup Get**.

Pulses A defines the number of pulses in pulse group A (max. 10).

Pulses B defines the number of pulses in pulse group B (max. 10).

RepRate defines the repetition rate in kHz.

After entering all parameters press **Set** to transmit and activate the data set. An actual data set can be requested by pressing **Get**.

5 Operation

In this chapter the mainly used operations to control the HYPER RAPID 25 laser are described. There are two possible types of controlling the laser :

- direct control
- external control

5.1 Direct control

Via the HYPER RAPID 25 software on the control unit the HYPER RAPID 25 laser can be controlled directly.

5.1.1 Starting the laser

Please make sure that signal cables are connected before the turn-on sequence is initialised (in order to prevent false signals). Also all interlock chains have to be closed, otherwise the system might not turn on or the shutter might not open (refer to the corresponding chapters: key switch, emergency stop, IL/Shutter connector).

Previous chapters, especially "Safety issues", have to be read and fulfilled. The laser beam has to be adequately protected, covered and guided to a defined place (e.g. a beam dump for testing purposes). Laser - protective clothing as well as adequate eye protection have to be worn. Installation procedures have to be followed. Involved persons have to be advised of danger.

To start the HYPER RAPID 25 laser, proceed as follows:

1. Turn on the Zero-Air Generator
2. Make sure that the HV switch (located on the rear side of the control unit) is turned on (and can always remain "on").
3. Turn the key switch on the control unit(front side) to the ON position.
4. Switch on the main switch of the control unit. The switch shines green. The control unit starts a self test and then initialises the laser head. The LEDs on the control unit blink orange. The integrated PC is loading the Windows operation system.
5. The chiller gets turned on automatically by the control unit.
6. Turn on the monitor of the integrated PC.
7. On the integrated PC's desktop start the Rapid Control software with a double click. The main window opens, see section "Main window" on page 41.
8. The LEDs of the control unit will shine orange to indicate the standby mode and the system ready state.

9. When the LEDs on the control unit shine orange, select **Start** in the Rapid Control main window. First the seeder laser, then the amplifiers and the delay generator are turned on. The LEDs on the control unit shine green.
10. Select **Open** to open the shutter and emit the laser beam. Before this is allowed make sure that laser safety is fulfilled. The beam has to be guided to an adequate position (or into a beam dump for testing purposes).

It is also possible is to turn on all power supplies at the same time (make sure to provide adequate switching devices, cable sizes and fuses designed for the corresponding total amount of power and inrush-current/max. current (refer to identification label located on the power supply).

5.1.2 Stopping the laser

To stop the HYPER RAPID 25 laser, proceed as follows:

1. In the main window of the Rapid Control software select **Stop**.
2. Close the main window, see section "Main window" on page 41.
3. Shut-down the internal PC within the control unit (Start/Shutdown).
4. Switch off the main switch of the control unit. The control unit shuts down the laser head and the integrated PC.
5. Turn the key switch on the control unit to the OFF position.
6. Turn off the monitor of the integrated PC.
7. Turn off the Zero-Air Generator

The turn-off procedure just happens in opposite order compared to the turn-on procedure. Alternatevely it is also possible to turn off all power supplies at the same time.

5.2 External control

In order to operate the HYPER RAPID 25 laser in a superior machine, the control can be done by transmitting external commands via network (DLL).

Prerequisites

- Server application is configured and running (on the integrated PC).
- Client application is installed and configured (on the external PC).
- Network is configured and functional. The communication port numbers are defined (on both sides).
- The laser is started.

Controlling via command

The following list shows a typical sequence of commands from the RapidClient.dll, in order to control the HYPER RAPID 25 laser:

1. Open the command prompt on the external PC: (Start/Programs/Accessories/Command prompt).
2. Change to the `C:\Rapid\Rapid_Client` directory.
3. Enter `ConnectToServer()` (establishes the connection to the control unit PC). In case this is not successful, check the connection and its settings. Change them if necessary with `SetConnectionSettings()`.

4. Enter `StatusGet()` to check the laser status.
5. When the status changes from "INITIALIZING" to "LASER OFF" enter `LaserStart()` to power on the HYPER RAPID 25 laser.
6. When the status changes to "LASER ON" enter `ShutterStateSet(1)` to open the shutter. Warning: Fulfill laser safety! The laser beam needs to be directed (beam dump for testing purposes). Use: `ShutterStateSet(0)` to close the shutter.
7. In order to request the IR output power use `IRPowerLevelGet()` (return value in Watt). The usage of this command depends on the configuration of the laser. When for example the SHG module exclusively produces green light, there is no IR output power therefore sending this command would return 0.
8. Enter: `LaserStop()`, in order to turn off the laser.
9. After the state changes to `LASER OFF` use `DisconnectFromServer()` in order to disconnect the link between the control unit and the external PC.

For further commands refer to the description “RAPID DLL Specification” (located on the documentation CD). For periodical information retrieval like e.g. `StatusGet()` or `ErrorGet()` a repeating loop is recommended.

6 Maintenance

The HYPER RAPID 25 laser is constructed for low maintenance operation. Periodical maintenance described in this chapter is necessary to be performed by the customer.

6.1 Hardware maintenance

Service and replacement of components is limited to LUMERA LASER Service personnel.

The instructions of this User's Guide have to be strictly followed. All danger signs have to be observed. Use only original parts for repair and replacement. Do not change / switch components from different OEM solid state lasers without consulting LUMERA LASER GmbH.

The HYPER RAPID 25 laser is a class 4 / class IV OEM laser.

Before using or maintaining the laser, make sure that

- the laser is installed correctly.
- In case the mains voltage deviates from 230 V, the transformer (optionally included in the delivery) is required and needs to be adjusted correctly to the house voltage. All delivered supply components have to be connected to the transformer.
- the air ventilation slots are clear and the laser head is mounted securely.
- the external interlock circuits are properly connected and functioning (e.g. IL/Shutter connector must be connected).
- laser shutter is closed.
- the beam output aims securely into a beam dump.
- all safety aspects are considered.
- no moisture can condense.
- the control unit and the chiller are disconnected from mains.
- the user is informed / trained to operate the laser system safely and in compliance with all regulation for such OEM laser systems, and that all statements of this manual are known and observed.
- Clean the systems if necessary by using a clean cloth without any liquids. Inside a clean-room lint-free material (and maybe further more constrictive properties) might be required.

Avoid aggressive gases, dust, explosive atmosphere. Protect against frost.

Disconnection of the pumping fibers is to be performed only by qualified personnel trained by LUMERA LASER GmbH. Make sure, that the laser system is switched off and disconnected from the power source.

6.1.1 Changing the desiccant cartridge in the laser head

The laser head has 2 desiccant cartridges, which are screwed into the head, see section "Laser head" on page 24. A new desiccant cartridge has a blue colour. Collecting moisture results in a colour change over grey-violet to light-pink. Then cartridge has to be changed.

new **contains moisture** **change cartridge**

Figure 29: colour index of the desiccant cartridge

Changing the desiccant cartridge is only allowed in a clean environment to avoid contamination of the laser head, e.g., dust swirls through air condition. In case these conditions are not able to fulfil, it is recommended to contact LUMERA LASER GmbH. Follow the procedure described below:

1. Plug off and disconnect the control unit.
2. Unscrew the old desiccant cartridge. The package container has a ledge bar which can be helpful for unscrewing the cartridge. Remove the old cartridge just shortly before the new one is ready to be inserted in order to reduce the open-time of the laser head housing.
3. Replace the used cartridge with a new one. Important is to make sure that the rubber-sealing and its bearing surface are completely clean.
4. Reconnect the control unit.

6.1.2 Maintaining the chiller

It is recommended to maintain the chiller every six months.

Always wear gloves, protective goggles and protective clothing when maintaining the chiller. The coolant liquid contains corrosive components, which are not allowed to come in contact with eyes or skin. Caution with all apparatus openings, water could splash out uncontrolled. All information located in the chiller manual have to be observed.

Maintenance tasks for the chiller are:

- Changing the coolant: use de-ionised water. The electrical conductance of the water shall be smaller than 10 µS/cm (typically 2-5 µS/cm) [Siemens=1/Ω]. Before filling the chiller, mix the water with the adequate additives. A first installation kit is included in the delivery. The necessary proportion of mixture is marked on the bottles and needs to be observed. Do not use any other additive than the ones which are delivered (corrosion-inhibitor and biocide).
- Changing the filter: We recommend to change filter and water at the same time (time interval deviates from the information in the chiller user manual).

6.1.2.1 Instruction for coolant and filter change

Drain coolant water from chiller

- remove hoses from the rear side of the chiller (disconnect CPC couplings).
- disconnect all electrical connections and mains cable from power.
- remove screws from front side.
- drag chiller out of the rack (recommended to do this with 2 persons). Protect against drop and put the device onto an adequate platform (in order to reach the drain screw).
- position container (approx. 1.3 US gallons or 5 litres) under the drain outlet. The drain screw is located on the bottom of the chiller on the right front end (seen from the front).
- open drain screw with a metric 17 mm fork spanner and let the coolant flow into the container.
- open tank inlet (chiller front side).
- attach short hoses (water change kit, included in delivery) with CPC couplings into the connectors located on the chiller's rear side.
- use clean compressed air (with low pressure of max. 0.4 bar) to blow out remaining water. Observe the water flow direction! Keep away from device openings!
- close drain screw (hand tight + 1/8 turn; sealing shall tighten not crush).
- close tank inlet (chiller front side).
- remove water change kit from the couplings located on the chiller's rear side.

Drain coolant water from laser head & control unit

- connect water change kit (use corresponding CPC couplings) to the laser head hoses (hose end - chiller side). For this purpose different CPC couplings are included in delivery. Let the coolant drain into the container.
- use clean compressed air (with low pressure of max. 0.4 bar) to blow out remaining water. Observe the water flow direction! Keep away from device openings!
- remove water change kit.
- connect water change kit (use corresponding CPC couplings) to the control unit (rear side). Use the corresponding couplings and drain the coolant into the container.
- use clean compressed air (with low pressure of max. 0.4 bar) to blow out remaining water. Observe the water flow direction! Keep away from device openings!

Filter exchange

- loosen screws on the left side panel (seen from front) with metric Allen key 2.5, shift side panel slightly to the back and remove it from the device. Take care of the ground wire.
- dismount transparent filter housing by loosening the large thread-ring. The water level inside the transparent housing should be below max. (due to the water drain). Remove the rest of the coolant and clean the housing if necessary. Take care of the O-ring sealing.
- dismount and replace filter (make sure to mount the filter straight into position).
- mount filter housing together with the o-ring back at its position and tighten the thread-ring.

- close side panel.
- reinstall chiller back into the rack and tighten front screws.
- reconnect all hoses of the chiller system. Observe the correct flow direction: chiller -> laser head -> control unit -> chiller.
- reconnect all electrical connections (mains and communication).

Refill coolant water

- in order to replace the full amount of coolant liquid prepare approximately 1.3 US gallons or 5 litres. Make sure to add the above mentioned additives.
- turn off the chiller.
- open tank inlet and bleeding (chiller front side). This is only permitted as long as the chiller is deactivated.
- fill in approx. 0.5 - 0.8 US gallons (2-3 litre) of coolant liquid until the indicated maximum level is reached.
- close tank inlet and bleeding. Never turn on the chiller with open inlet or bleeding (coolant could extrude).
- turn on chiller. The pump starts working and will stop with the warning/error "water level". An acoustic signal indicates this warning.
- Repeat the filling procedure and confirm the message with "quit" (button ⬇ chiller front side). By pressing "Ein/On" ⬆ the pump starts working again.
- Repeat this process until the noise of the pump normalises and the water level does not change any more.

After changing coolant water and filter, you should reset the counter in the Rapid Software, see section "Service menu" on page 48.

6.1.3 Maintaining the Zero-Air Generator

We recommend to maintain the Zero-Air generator every 12 months. Maintenance is related to changing the filter pad (front side) and both filter elements (rear side). For this purpose one filter set (filter change kit) is included in the delivery. An exchange also might be necessary more often and needs to be performed according to environmental circumstances.

6.1.3.1 Exchange filter pad

In order to exchange the filter pad remove the front grid, take out the filter and replace it with a new one. The grid has to be attached again.

Figure 30: exchange the filter pad

Exchanging the filter can be done during device operation as long as inserting a new filter is done promptly after removing the used one. Do not turn over (flip) the used filter (particles would be drawn into the device).

6.1.3.2 Exchange filter elements

Turn off the laser system and the Zero-Air generator in order to exchange the filter elements (located on the rear side of the device). Disconnect all mains plugs. Also make sure that air hoses connected to the device are pressureless.

In order to decompress the air-supply hoses it might be necessary to turn off the air-compressor or in case of a company-internal air-supply to close the appropriate track. Disconnect the accordant hose.

Disconnecting pressured hoses can produce a loud noise.

Disconnect the "inlet" and "outlet" hoses from the Zero-Air generator by pressing the ring of the push-in-fitting and simultaneously pull out the hose. The hose going to the laser head needs to be closed with the red cap (located in the transparent diode-kit package in the accessory box). Disconnecting these hoses is not necessary in case they are already pressureless.

Unscrew the housings by hand. Using any tool is not allowed and not necessary as long as the air-inlets are without pressure. Unscrew the white filter element with a cross recess screwdriver (Phillips) and replace it. The black filter element can be exchanged by unscrewing it by hand.

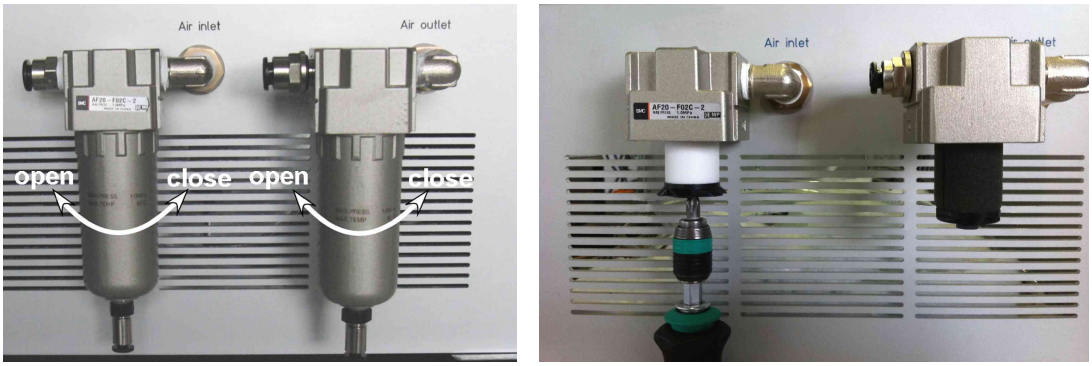


Figure 31: exchange of the filter elements

Assemble all parts in opposite order, activate air-pressure, connect mains and turn on devices.

6.1.3.3 Releasing condensed water

Due to the very low amount of air-flow there should not be any condensing water. Therefore it is not necessary to release any water. In case condensed water is collected, it automatically gets drained downwards (below the filter elements, rear side of the Zero-Air generator). In order to prevent uncontrolled drainage, two hoses (outer diameter 4 mm) can be connected if necessary.

6.2 Software maintenance

In case of an optical power drop the software supported maintenance can increase the laser power and recover the laser performance. Therefore the so-called S-Control software is available. The S-Control changes the spot position of the seed laser and thus optimises the performance of the HYPER RAPID 25 laser.

Software maintenance encompasses 10 cycles. The present cycle is displayed in the S-Control main window. Here also the number of available spots is displayed, see section "Starting S-Control" on page 65. If the S-Control software detects a problem, it displays a message, see section "S-Control messages" on page 66.

After starting the S-Control software the HYPER RAPID 25 laser is in maintenance state. During this state no other application of the laser is possible.

After the S-Control software has found a new optimisation position (maintenance spot), it finalizes software maintenance. The remaining spot number is decreased and the status is updated. The status of the laser system is changed from maintenance to operational mode.

6.2.1 Starting S-Control

The S-Control software is preinstalled on the control unit. In order to start the S-Control program, proceed the following:

Prerequisites

- The laser diodes are turned off.
- The Rapid Control software is closed.
- the Server Application is started (LL_Server.exe).
- The Shutter is closed. In case of an external shutter control, shutter needs to be closed externally.

Start S-Control

1. Double click the icon **S-Control** on the integrated PC's desktop.
2. Enter the password `gogogo`.
3. The S-Control window opens displaying the present state of the HYPER RAPID 25 laser. The program checks the shutter position. In case the shutter is open and cannot be closed, the shutter as well as the program needs to be closed by the user. Restart S-Control again. Initialising can take up to half a minute.

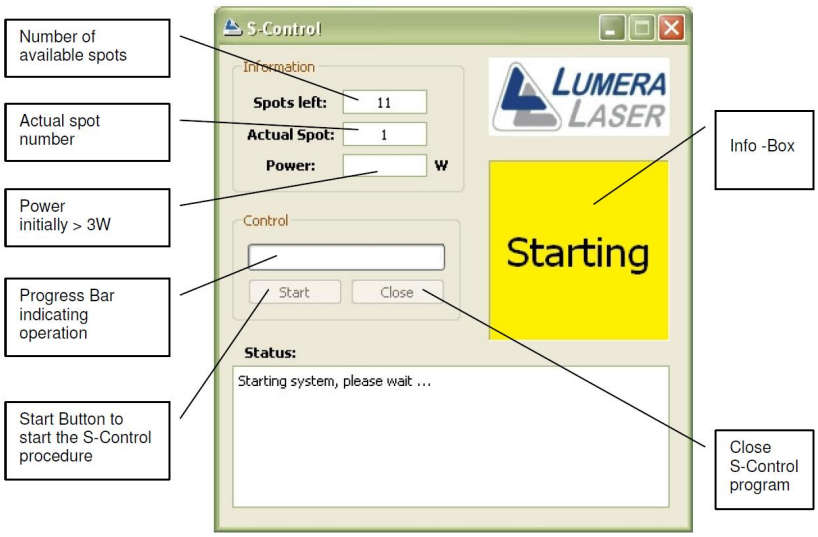


Figure 32: S-Control main window

Spots left

number of spots which are still available. After each maintenance cycle this number decreases by 1. When the number changes to 0, a Service assignment is necessary. Please contact LUMERA LASER GmbH.

Actual Spot:

actual spot number.

Power

internally measured seeder power.

Start
starts the software maintenance. After a successful cycle the number of remaining spots decreases.

Close
closes the program.

Status
displays information concerning the S-Control program and the state of the execution, see section "S-Control messages" on page 66.

6.2.2 S-Control messages

If the S-Control software detects a problem during software maintenance, it displays a message:

Message	Description	Recommendation
Unfinished maintenance procedure detected. Do you want to continue this procedure?	Interrupted maintenance procedure.	Contact LUMERA LASER GmbH.
DLL functions not resolved. DLL is missing or wrong version.	`Rapid_Server` program for external control is missing or wrong version.	Check if the Rapid_Server is started. Check if server and client version are equal.
No connection to Driver established. Check serial port or connection cable.	No connection to the laser head established.	Check serial port and/or connection cable.
Driver error received. ID: (ErrorNumber)	Driver error.	Contact LUMERA LASER GmbH.
Driver switched off. Before restart, switch on driver.	A hardware driver controlling the laser head is switched off.	Restart S-Control software, see section "Starting S-Control" on page 65.
Rapid dynamic link library is not connected. Maintenance is not possible in this state.	DLL not connected to server!	check if Server is running, check versions.
Rapid dynamic link library is not able to close shutter. Maybe there is an external shutter control set.	Shutter could not be closed; might be controlled externally.	Check shutter or close shutter externally.
Rapid dynamic link library reports an error. The laser system might be switched off.	DLL reports an error.	check if Server is running, check versions.
The laser must be on to start maintenance. Please turn on the Laser and start again	No Power detected.	Start the laser, see section "Starting the laser" on page 55.

Message	Description	Recommendation
The laser system detected a problem. Check the laser system and restart the program.	The HYPER RAPID 25 laser is off.	Check connection control unit and laser head. Check laser state.
All available spots were used. Contact LUMERA LASER GmbH.	There are no more spots left over.	Full maintenance necessary: LUMERA LASER GmbH.
Unfinished maintenance procedure detected. Continue anyway with full repeats?	incomplete maintenance, do you want to continue procedure?	contact LUMERA LASER GmbH.
Low Powermove detected. Do you want to continue this procedure?	Power drop detected. Continue procedure?	Search maximum power manually or contact LUMERA LASER GmbH.
First motor moving failed! Possible motor defect or connection problem.	First motor does not move.	Check all cable connections between control unit and laser head.
Second motor moving failed! Possible motor defect or connection problem.	Second motor does not move.	Check all cable connections between control unit and laser head.
Only (n_SpotsLeft) Spot(s) left. Maintenance required.	Warning that the number of available spots gets low. Full maintenance is near.	Contact LUMERA LASER GmbH for service schedule.
Not enough power available. Maybe there is a new maintenance cycle necessary.	The available power after maintenance cycle is lower than 2.5 W. Bad position or no optimisation positions left.	Repeat software maintenance or contact LUMERA LASER GmbH.

7 Glossary

A

Air flow

When a wavelength conversion module (SHG, THG or FHG) belongs to the system, the module at the front-side of the laser head is purged with cleaned air comming from the Zero-Air generator.

Amplifier

Device which receives some input signal and generates an output signal with higher optical power. Typically, inputs and outputs are laser beams, either optically or electrically pumped.

B

Beam splitter

Optical device that splits an incident light beam (e.g. a laser beam) into two or more beams, which may or may not have the same optical power.

BNC

Bayonet Neill-Concelman

Burst mode

In burst mode the laser emits a defined amount (0 to 10) of pulses separated by 20 ns.

C

Chiller

Cooling device for the laser system. There are wo different chillers available: water to air chiller or water to water chiller.

Control unit

The control unit consists of the power supply, the chiller, an inbuilt PC, a monitor and a keyboard. All devices are packed in a 19" rack.

Coolant

Cooling liquid within the chiller. The coolant consists of de-ionized water mixed with bio-cide and anti-corrosion additive.

CPC coupling

This is a quick-lock coupling for water hose connections.

CU

control unit; laser power supply

D

Data logger

The data logger records shock or vibrations during transport of the laser system. The data logger resides in the shipping crate and has to be send back to LUMERA LASER.

Delay generator

Internal PC card that controls the laser timing, e.g., adjusting frequencies.

DLL

Dynamic Link Library

E

EOM

Electro-optical modulator. A device which is used for controlling the power, phase or polarisation of a laser beam via an electrical signal. It typically contains Pockels cells and additional optical elements such as polarizers. It is also called pulse picker.

External EOM

Optional device (included in the module if ordered) which controls the optical pulses (gating).

F

Faraday isolator

Kind of optical isolator, i.e., a device which transmits light in a certain direction while blocking light in the opposite direction. Faraday isolators are based on Faraday rotators and constitute the technologically most important type of optical isolators.

Faraday rotator

Magneto-optic device, where light is transmitted through a transparent medium which is exposed to a magnetic field. The magnetic field lines have approximately the same direction as the beam direction, or the opposite direction. If the light is linearly polarised in some direction, this polarisation direction is continuously rotated during the passage through the medium.

FHG

Fourth Harmonic Generation. Frequency quadrupling is a process of nonlinear frequency conversion where the resulting optical frequency is four times that of the input laser

beam, which means that the wavelength is reduced by a factor 4.

Fiber

Optical fibers are a kind of waveguides, which are usually made of some kind of glass, can potentially be very long (hundreds of kilometers), and are – in contrast to other waveguides – fairly flexible. The most commonly used glass is silica, either in pure form or with some dopants. Optical fibers connect the pump diodes in the control unit with the laser head.

Fiberscope

Optical inspection decvice for optical fibers.

Function generator

Refer to Pulse generator

G

Gate

TTL signal in order to switch the laser beam optically. TTL high enables the output of laser radiation, TTL low inhibits emission (residual radiation possible).

GND

Ground connection

GUI

Graphical User Interface

H

HV

High Voltage

I

Interlock

Safety device for automatically switching off a laser power or interrupting a laser beam.

IR

Infrared. Electromagnetic radiation above the visible range for the human eye. Here infrared indicates a wavelength of 1064 nm.

L

Laser diode

Electrically pumped semiconductor lasers in which the gain is generated by an electrical current. The laser diodes reside in the control unit.

LD

Laser diode

LED

Light Emitting Diode

LSO

Laser safety officer. A company internal person has to be announced and (externally) certified.

M

Mode locking

Method to obtain ultrashort pulses from lasers, which are then called mode-locked lasers. Here, the laser resonator contains either an active element (an optical modulator) or a nonlinear passive element (a saturable absorber), which causes the formation of an ultrashort pulse circulating in the laser resonator.

Modulator

Device which can be used for manipulating a property of light e.g. a laser beam.

Module

Optical unit which will be attached to the laser head during manufacturing. It can be a frequency conversion module and/or an external EOM.

O

OEM

Original Equipment Manufacturer

Oscillation

Repetitive variation, typically in time, of some measure about a central value (often a point of equilibrium) or between two or more different states. Familiar examples include a swinging pendulum and AC power. The term vibration is sometimes used more narrowly to mean a mechanical oscillation but sometimes is used to be synonymous with "oscillation."

P

PD

Photo diode, internal optical power measurement

PM

Powermeter, external optical power measurement

Polarisation

Property of waves that describes the orientation of their oscillations. Electromagnetic waves such as light, along with other types of wave, exhibit polarisation.

PRF

Pulse repetition frequency

Pulse

Flashes of light generated with a laser (laser pulse) and delivered in the form of a laser beam. Due to the enormously high optical frequencies, optical pulses can be extremely short (ultrashort) when their optical bandwidth spans a significant fraction of the mean frequency.

Pulse generator

External device, capable of generating TTL signals with an adjustable frequency and phase. Might also be called 'function generator'. A frequency generator might not include this functionality.

Pulse group

Group with a defined amount of pulses. The time interval between two adjacent pulses is 20 ns.

Pulse picker

Refer to EOM

Pulse sequence

Refer to pulse group

R

Repetition rate

Also pulse repetition frequency, defines the number of emitted pulses per second, or the reciprocal temporal pulse spacing (abbr.: rep.-rate). Unit adressed in kHz or MHz.

RS-232

Recommended Standard 232 (computer serial interface, IEEE)

RU

Rack Unit, 1.75 inches (sometimes Unit, U), 44.45mm

S

Seed oscillator

Also seeder, laser which is used for generating seed light pulses of high repetition rate leading into an amplifier or another laser.

SHG

Second Harmonic Generation. Frequency doubling is a process, where an input (pump) wave generates another wave with twice the optical frequency (i.e. half the wavelength) in the medium. In most cases, the pump wave is delivered in the form of a laser beam, and the frequency-doubled (second-harmonic) wave is generated in the form of a beam propagating in a similar direction.

Shutter

Safety device in the laser head used to interrupt the emitted light during laser operation.

T

TEM00

Transverse mode, describes the quality of the beam profile

THG

Third Harmonic Generation. Frequency tripling is a process of nonlinear frequency conversion where the resulting optical frequency is three times that of the input laser beam.

Trigger

TTL signal in order to define a pulse repetition rate.

TTL

Transistor Transistor Logic, digital signal with 0 or 5V.

U

UV

Ultraviolet. Electromagnetic radiation with a wavelength shorter than that of visible light, but longer than x-rays; approx. in the range 10 nm to 380 nm.

V

VAC

Voltage in alternating current

Variable attenuator

Device in the laser head that attenuates the power of the laser beam.

8 Index

T

W

Z